State of the Art on the Monitoring of the Pine Wood Nematode –PWN (*Bursaphelenchus xylophilus*) and its Insect Vector (*Monochamus galloprovincialis*) in Europe

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Cerambycids Chemical Ecology

Monochamus galloprovincialis Olivier

I. Introduction

The commonly long-horned beetle or longicorn beetles belong to the family of Cerambycidae comprises a group of phytophagous Coleoptera. The larvae are also known as round-headed borers and most of them feed upon the solid tissues of living, dead, or dying plants or in rotten wood. The various stages of a gradually disintegrating tree have their particular species, some in the living parts, and others in the recently dead material, and still others in the wood which has seasoned for several years. As would be expected, their role in this succession varies from host to host and region to region. Distributed world-wide from sea level to montane sites as high as 4,200 m elevation wherever their host plants are found, cerambycids have long been a favourite with collectors (Linsley, 1959).

Cerambycids constitute one of the largest groups of insects with not less than 35000 described species (Lawrence, 1982). Seven subfamilies are currently recognized: Anoplordermatinae, Aseminae, Cerambycinae, Lamiinae, Lepturinae, Prioninae, Spondylidinae and they are distributed worldwide (Lawrence 1982).

Economic Importance

Forests

The cerambycids, in general, have a beneficial role and reduce the number of dead and dying trees since they consume dead wood. But in the case of storms or fires in the forested regions Cerambycidae may destroy the wood before it can be utilized. Adults of some cerambycid species select healthy trees for oviposition whereas others select fire damaged trees or drought stressed, wind thrown or severely defoliated trees. More than 90 species have been listed to be attacking living broadleaf shrubs and trees (Solomon, 1995). Cerambycids have also been implicated in the transmission of diseases of forest trees. Cerambycid larvae often negatively impact resources by feeding in roots, stems or trunks of host tissues (Hanks 1999). The cryptic habit of these beetles has made detecting cerambycids in imported products difficult. Exotic species, such as the Asian longhorn beetle, *Anoplophora glabripennis* (Motschulsky), have had a large impact on urban areas, killing thousands of trees in the Eastern United States (Macleod et al. 2002). Introduction of exotic cerambycids by means of nursery stock and wood products has increased the need to monitor for their presence (Hanks et al. 1993, Allison et al. 2004, Sweeny et al. 2004). One of the most important current diseases in pines

and other conifers is the pine wilt disease caused by the the pine wood nematode (PWN) *Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle (Mamiya 1988; Kishi 1995). The nematode is transported as fourth-stage dispersal juveniles by cerambycid beetles of the genus *Monochamus*, considered to be the most important vectors worldwide (Linit 1988, 1990; Kishi 1995). In Japan, *Monochamus alternatus* is the most important vector of *B. xylophilus* (Mamiya and Enda 1972; Kishi 1995), and *M. carolinensis* in the United States (Linit 1987, 1988). Soon after its introduction into Portugal in 1999, the PWN was found associated with the endemic beetle species *Monochamus galloprovincialis* Olivier (Sousa et al. 2001).
Cerambycid larvae may cause serious defects in lumber, either by attacking living trees or by attacking shortly before cut logs are sawed. In temperate forests, the resultant reduction in grade probably causes a greater monetary loss than do the tree-killing species.

The need for greater knowledge of chemical ecology within the family Cerambycidae has increased due to the introduction of exotics, their role as pests in agricultural settings and their impact on forest biodiversity (Allison et al 2004).

II. Host Selection in forest Coleoptera (Cerambycidae and scolytidae)

All phytophagous insects are to some extent selective in their choice of host plant for feeding, survival, and development. Selection does not only involve finding an appropriate plant habitat and species, but also the most suitable individual or plant. To select a host-plant, the insect must first be able to detect and locate it from a distance and thereafter confirm the quality of it. Plant chemicals are of great importance for host-plant selection and are classified according to their effects on insect behaviour (Dethier, et al. 1961). Attractants and repellents make the insect move towards or away from the plant, as they affect insects at a distance from the plant. Feeding/oviposition stimulants and deterrents elicit or inhibit feeding or oviposition when the insect has reached contact with plant tissue. This classification is functional and based on the biology of each insect. A chemical that functions as an attractant to one insect species may be a repellent to another. The concentration of a chemical may also affect insect behaviour: an attractant may function as a repellent when the concentration exceeds a certain threshold (Bernays and Chapman 1994). When a plant is accepted, food intake is mainly controlled by the detection of chemical stimuli. In general, primary metabolites (nutrients) stimulate feeding while secondary metabolites (non-nutrients) do not. However, some secondary metabolites are of great importance in stimulating feeding and are then termed "token stimuli" (Steiner 1984).

Chemical cues

Linsley (1959) speculated that the dominant sensory modality for host seeking cerambycids is olfaction, with adult beetles responding to host and host-related volatiles or sex pheromones. The last step in the host selection phase by cerambycids is acceptance of a host for maturation feeding or oviposition. In the Cerambycidae, larval hosts, are chosen by sexually mature egg-laying females (Linsley 1959). Because the larvae cannot disperse, oviposition in nonhost species or low quality hosts can have significant fitness consequences. However, Linsley did not conduct laboratory bioassays to determine the presence of semiochemicals but made conclusions on morphological differences between female and male antennae.

Chemoreception is often used to locate food sources or oviposition sites. Ikeda (1993) found that floral volatiles attract cerambycids that typically feed on nectar or pollen. Antennal stimulation of *Anaglyptus subfasciatus* Pic and *Demonax transilis* Bates with fourteen different components of a floral extract indicated strong reaction toward floral volatiles (Ikeda et al. 1993). Field tests confirmed that benzyl acetate and methyl phenyloxyacetate in floral extracts caught significantly more *A. subfasciatus* and *D. transilis* beetles than did the control (Nakamuta et al 1997).

The fact that insects are able to locate highly specific habitats was demonstrated in a study on the whitespotted sawyer (*Monochamus scutellatus*) (Coleoptera: Cerambycidae) (Saint-Germain et al., 2004). This species can only reproduce successfully on heavily stressed trees and is frequently found in recently burned forests. However, during the reproductive phase, adults of *Monochamus* species also need to feed on healthy trees. The results from the study showed that plots of burned forest that had a high percentage of healthy, unburned forest in the proximity were the most intensely colonized. This result suggested that large-scale habitat location mechanisms play an important role in the host selection process, but the sensory cues used in habitat location could, unfortunately, not be determined in their study (Saint-Germain et al., 2004).

Other insects that use chemical cues to determine ost speciity during their feeding phase are the *Tomicus* (Coleoptera: Scolytidae). Recent studies have focused on the montoterpenes that may attract feeding females. Faccoli *et al* (2008) used two blends of two (α-pinene and β-myrcene; blend A) and three (α-pinene, β- myrcene, and α-terpinolene; blend B) synthetic compounds, chosen among those that induce EAD responses and known to be attractive for other bark beetle species. In olfactometer, insect behavior was affected by the degree of sexual maturation but not by sex. Callow insects (feeding insects) were attracted by shoots

and their extracts, while mature (ovipositing) individuals by bark and its extracts. Six extracted compounds were active on *T. destruens* antennae: limonene, (*Z*)-3-hexen-1-ol and β-caryophyllene, α-pinene, β-myrcene, and α-terpinolene. α-Terpinolene, released only by bark, was active only on mature insects, whereas (*Z*)-3-hexen-1-ol, released only by shoots, was active only on feeding individuals. Males and females showed similar EAD responses. Of the six extracted volatiles, two were attractive for callow adults (blend A) and three for matures (blend B) (Faccoli et al., 2008). Another study (Almquist *et* al, 2006) on *Tomicus piniperda,* showed that the dominating monoterpenes in five *Pinus* species originating from France (*Pinus sylvestris, P. halepensis, P. nigra laricio, P. pinaster maritima, P. pinaster mesogeensis*) were (-)-*α*-pinene, (+)-*α*-pinene, (-)-*β*-pinene and (+)-3-carene. The study showed that pine species can be divided into two according to their monoterpene profiles and the trees that are highly attacked and feed upon belongs to the group of (-)-*α*-pinene and (-)-*β*-pinene.

Visual cues

The only study to date about the importance of visual cues in Cerambycids is by Fukaya *et al* (2005). However, the study aimed at locating the male by the female of *Anoplophora malasiaca* in a series of bioassays under laboratory conditions. Visual cues can play a role in in enhancing host selection.

Gustatory cues

After the orientation and host selection phase, insect food ingestion process is followed by storage in the initial portion of the alimentary canal. Digestion and absorption takes place in the mid gut, with an entry of the nutrients into the metabolic cycles that is completed with excretion of waste and undigested material. Different feeding inhibitors cause different changes in the physiological mechanisms operating at each level. A preingestive inhibitor that affects chemosensory cells in sensillas on antennae and tarsi causes reduced palpation while a postingestive inhibitor targeting midgut muscles may cause gut movements. A reaction caused by preingestive inhibition is furthermore usually a rapid reaction while postingestive inhibition reactions take longer time and produce more chronic effects (Frazier and Chyb 1995). Several allomones have been detected for cerambycids but they were all involved in the host searching selection phase and were of sesquiterpene natures (Annex 1). No study until todate have tackled the role of antifeedants in host trees in relation to cerambycids.

Manson (2005) have demonstrated the antifeedant properties of octanoic, nonanoic and decanoic acid against the pine weevil, *Hylobius abietis* (coleopteran: curcullionidae).

III. Sexual and aggregation pheromones of Cermabycids

In the last 25 years, several studies of Cerambycidae have described the behaviors associated with using semiochemicals to locate and recognize mates (Gardiner 1957, Hanks 1999, Allison et al. 2004).

Long range pheromones

For most cerambycids, adult males usually play the active role in mate location (Linsley, 1959). It has long been held that these beetles, like most other insects, depend on pheromones that act over long distances for mate location; however, convincing evidence of long-range pheromones in the cerambycids has been limited to a very few species and is often coincident with the lack of feeding in the adult stage and sedentary behavior in the pheromone-producing sex. Pheromones that act over long distances appear to be rather rare in the Cerambycidae, a circumstance that correlates well with antennal morphology. Sensitivity to long-range pheromones in other insects is enhanced by increasing the surface area of the antennae (and hence the abundance of olfactory sensilla), leading to the evolution of branched antennae that are lamellate, pectinate, serrate, etc (Schneider, 1964). The majority of cerambycids have antennae that are nearly filiform, but relatively elongate, a structure not especially well suited for sensitivity to long-range pheromones (Schneider, 1964).

These long-range attractants are also chemically similar. Species that utilize distance pheromones typically synthesize alphahydroketones or alpha-beta diols that range in length from six to ten carbons (Iwabuchi 1986, Nakumuta et al 1994, Schroder et al. 1994, Fettkother et al. 1995, Noldt et al. 1995, Ginzel and Hanks 2003, Allison et al. 2004, Lacey et al. 2004). These compounds are often emitted by glands on the male prothorax.

Short range pheromones

Pheromones that operate over at least moderate distances (»1 m) are produced by females of the root-feeding anoplodermine *M. fryanus* (Leal *et al*, 1994), males of the dry-wood feeder *H. bajulus* (Fettkother *et al*, 1995), and of the vine-boring *X. pyrrhoderus* (Iwabuchi, 1988). Such pheromones are also suspected in male *Xylotrechus chinensis* and female *S. bicolor* (i Itami *et al*, 1989), both cerambycines.

Cerambycidae may also detect receptive mates at shorter distances through the use of cuticular hydrocarbons (Allison et al. 2004). Contact chemoreception occurs through recognition of specific multiple hydrocarbon strands embedded in the waxy cuticle of the insect (Blomquist 1996). Hydrocarbons are located on the female cuticle and have different functional groups attached, often methyl groups. Hydrocarbons can act as sex-specific labels that aide in species and gender recognition. Beetles utilizing cuticular hydrocarbon recognition are believed to have mutual attraction to a specific site, larval host, host-feeding site etc. (Hanks 1999, Ginzel et al 2003). After arriving on the mutually attractive host, beetles randomly search and locate viable mates. Insects unable to locate mates by means of long-range or short-range pheromones must rely on random encounters. The probability of locating a mate by chance is low, especially when a particular species has low population densities.

Observations

Careful observation of many lamiines has revealed that long-range pheromones are not involved in mate location (*A. vastator*, *A. chinensis*, *O. erythrocephala*, *O. schaumii*, *P. fortunei*, *P. rufiventris*, *S. inornata*, *S. populnea*); an inability to detect mates at long distances has also been reported for *Oberea oculata* L. (Hanks, 1999). Mate location appears to depend on males encountering females by chance (lamiines *A. chinensis*, *O. erythrocephala*, *O. schaumii*, *S. inornata*, *S. populnea*; cerambycines *N. cantori*, *Tragidion armatum*), and males recognizing females by antennal contact (lamiines *A. chinensis*, *P. rufiventris*, *P. hilaris*; cerambycine *M. robiniae*), by very short-range pheromones operating over distances of a few centimeters (lamiines *P. hilaris*, *P. fortunei*; cerambycine *S. japonicus*), or visually over similarly short distances (*P. rufiventris*). The probability of encountering a mate by chance on adult host plants, and hence mating opportunity, would seem to be very low, particularly on large host trees. Adults of some species, however, appear to improve their chances of encountering mates by seeking individual hosts of a particular type. For example, adults of *M. robiniae* prefer to visit goldenrod plants that are most conspicuous because they are isolated and have larger and brighter inflorescences (Hanks, 1999). Studies have also suggested the absence of long-range pheromones in some cerambycines: *P. semipunctata* and lamiines *M. alternatus*, *M. carolinensis*, *M. scutellatus*; (Linit, 1988).

Hanks et al. (1996) also speculated that the elongate, filiform structure of the antennae of many cerambycids is used for contact recognition mates; they also suggested that shorter antennal structure is not an evolutionary trait for contact communication, but instead is designed for pheromone communication. Hanks (1999) reviewed data on 20 species of cerambycids and concluded that long-range pheromones are not used throughout the family; however, long-range pheromones are observed in subfamilies Prioninae, Cerambycinae and Lamiinae. The hypothesis that elongate antennae have evolved specifically for contact chemoreception has not been substantiated. Relating the presence of gland pores on males to the length of antennae relative to body size of beetles within 3 tribes in the subfamily Cerambycinae, Ray (2005) determined that antennal length cannot be used as an indicator of pheromone use.

In general, short range pheromones are female produced and long range sexual pheromones are male produced.

The role of the host plant

Many cerambycid species utilize semiochemicals to locate hosts (Allison et al. 2004). Host volatiles are crucial in host selection in many insects and evidence indicates cerambycids are no exception (Hanks 1999). Trees under stress may alter the chemical compounds that are produced. Some cerambycids are attracted to ethanol and other monoterpenes produced by stressed trees (Ikeda et al. 1986, Chenier & Philogene 1989, Dunn & Potter 1991, Sweeney et al. 2004, Costello 2005). Most often mating occurs on the trees. Species such as *Arhopalus tristis F.,* which colonize fire-damaged trees, are thought to be attracted to burnt bark volatiles (Suckling 2001). White oaks produce volatiles that attract two-lined chestnut borer (Coleoptera: Buprestidae) (Dunn et al. 1986). However, host volatiles collected from northern red oaks have not elicited positive behavioral responses by red oak borer. Non-host compounds have been shown to repel cerambycids during host selection (Allison et al. 2004). Females avoid non-hosts because these plants produce repellents such as essential oils (Aojin and Qing'an 1998).

For cerambycid species that feed in the adult stage, mate location behavior is associated with larval host condition. Males often seek females at the adult feeding site, which is also the larval host (lamiines *A. carcharias*, *A. chinensis*, *A. glabripennis*, *A. malasiaca*, *O. erythrocephala*, *O. schaumii*, *P. scalator*, *S. candida*, *P. hilaris*; cerambycines *S. japonicus*, *X. pyrrhoderus*) or flowers of different species (cerambycines *A. moschata*, *M. robiniae*). In

some lamiine species, the male may remain near or mounted on his mate while she girdles the host branch or prepares the egg niche (*A. glabripennis*, *G. pulverulentus*, *O. cingulata*, *P. rufiventris*). In most species, however, the female usually oviposits alone.

IV Monochamus

The association of the pinewood nematode with insects in the genus *Monochamus* (Cerambycidae) appears to have along evolutionary history but it was not described until the widespread occurrence in Japan of nematode associated tree death now known as pine wilt.

Seven species of *Monochamus* are known as vectors of the PWN: *M. carolinensis* (Olivier, 1975), *M. mutator* (LeConte,), *M. scutellatus* (Say, 1824), *M. titillator* (Fabricius) in North America, *M. alternatus* (Hope, 1842), *M. saltuarius* (Gebler, 1830) in East Asia and *M. galloprovincialis* (Olivier, 1795) in Europe (Akbulut and Linit, 1999; Evans et al., 1996; Jikumaru and Togashi, 1995; Kiyohara and Tokushige, 1971; Mamiya, 1988; Mamiya and Enda, 1972). In 1993, a monitoring project (Pest Risk Analyses, PRA) has shown the existence of five endemic species of *Monochamus* on all the territories of the European Union (i.e. *M. galloprovincialis*, *M. sutor* (Linnaeus, 1758), *M. sartor* (Fabricius, 1787), *M. urussovi* (Fischer, 1806) et *M. saltuarius*). All the species are potential vectors of the PWN (Evans et al., 1996). Moreover, most of the pine species found in europe are considered susceptible to the disease (Evans et al., 1996). Following this study, *B. xylophilus* was classified as a quarantine pest for the European union (OEPP/EPPO 77/93, EEC, Evans et al. 1996).

Feeding behavior

Some aspects of the biology of European species have been presented by Hellrigl (1971), Starzyk and Hilszczanski (1997) and Tomminen (1993). According to these authors, after emergence, the beetle's maturation feeding takes place on the twig bark of healthy pine trees. When matured, the females use their mandibles to excavate slits in the bark of recently killed or weakened pine tree and lay one or two eggs in each wound. There are two periods of PWN penetration on pines: during beetle maturation feeding (Hellrigl, 1971; Naves, 2007; Togashi et al., 2004) when both sexes transmit the nematodes to healthy host trees via the feeding wounds, and during oviposition when females transmit them to dying trees via the oviposition wounds (Edwards and Linit, 1992; Mamiya and Enda, 1972; Morimoto and Iwasaki, 1972; Wingfield and Blanchette, 1983). The nematodes enter the beetle's tracheal system via the spiracles during the pupal stage (Hellrigl, 1971; Naves, 2007).

Both nutrition and oviposition were statistically more important on *P. sylvestris* but no difference was found with larval survival. Larvae developed more rapidly in *P. sylvestris* than in *P. pinaster* but they were bigger in *P. pinaster*, this result depending more on log size than on host tree species (koutroumpa, 2006).

Pheromones

In these species, mate location apparently depends on mutual attraction to the larval host where males rely on antennal contact to recognize females. Although Fauziah et al (1987) suggest that male *M. alternatus* produce a long-range pheromone, and Kim et al (1992) reported evidence of pheromones both by males (volatile pheromones) and females (contact pheromone in laboratory bioassays, field observations of Okomoto (1984) revealed that both sexes are independently attracted to the larval host where males locate females solely by antennal contact.

Ibeas *et al* (2008) conducted bioassays using Y-tube olfactometry that revealed that females of *M. gallopovincialis* were attracted to volatile compounds produced by males, but not to volatiles produced by females. However, immature males did not seem to release attractants for mature females and immature females did not show any attraction for mature males. An experiment designed to know about mating behaviour in this specie revealed that most of the males encountered females while they were walking. In all pairs both sexes contacted with antennae before copulation, however, in some occasions copulation did not proceed just after antennal contact. On the contrary, in all pairs observed, the male licked the elytra of the female with his mouth palpi just before copulation (licking); immediately afterwards, the male grabbed the female with his forelegs and mounted her suggesting a chemically mediated mate recognition by males. In 2009, Ibeas *et al* demonstrated the existence of contact sex pheromones on female *M. galloprovincialis* that help males recognize potential mates in close proximity. Differences in the cuticular hydrocarbon profile are likely involved in such recognition.

Conclusions

- All the species experimented with, the adults show a marked predilection for the host in which they have fed as larvae, provided they are not deterred by other factors, such as the unfavourable condition or the small quantity of the host;
- Ovipositing adults are influenced to a greater degree by the nature and condition of the host (i.e. thickness of bark, stage of decay, moisture content) than by the identity of the host species . . . ;
- Ovipositing adults (at least under laboratory conditions) are influenced by the amount and variety of hosts, irrespective of species.
- the long range pheromones of the genus *Monochamus* are male produced for several species; however, some work evidenced the presence of contact pheromones released by the female cuticle.
- There is no strong evidence of chemical cues whether pheromonal or kairomonal between the *Monochamu*s and the tree species.
- *Monochamus* seems to be attracted to a complex chemical cues yet simple when other wood bark beetles and stressed tress are present.

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Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
Monoterpenoid	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1R-α-pinene	R-alpha-pinene	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	A	O	wind tunnel	Fettköther	2000
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	A	O	Forest	Fan	2007
			Cerambycidae	Lamiinae	**Monochamus**	**urussovii**	Abies, Larix, Pivea, Pinus	Europe, Japan, China	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylinae	Arhopalus	tristis		Europe, Middle East, North Africa, China	A	O	Olfactometer	Suckling	2001
			Cerambycidae	Spondylinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylinae	Spondylis	buprestoides	Conifers	Europe, Asie	A	M & O	Forest	Sweeney	2004
Monoterpenoid	(1R)-6,6-Dimethyl-2-me	R-beta-pinene	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	A	O		Fettköther	2000
Monoterpenoid	(1R,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-ol; Cis-3-pinen-2-ol	pinenol	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	A		Olfactometer	Sakai	1991
Monoterpenoid	(1R,2S,5S)-Iridodial; C10H16O2	Iridodial	Cerambycidae	Cerambycinae	Chloridolum	loochooanum		Japan		Defense substance		Ohmura	2009
Monoterpenoid	(1S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1S-alpha-pinene	S-alpha-pinene	Cerambycidae	Cerambycinae	Xylotrechis	integer		North America	A	O	Forest	Miller	2006
			Cerambycidae	Cerambycinae	Xylotrechus	longitarsus		North America	A		Forest	McIntosh	2001
									A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	sagittatus sagittatus		North America	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	Acanthocinus	nodosus		USA	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	Acanthocinus	obsoletus		North America	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Fan	2007
			Cerambycidae	Lamiinae	**Monochamus**	**obtusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A	O	Forest	McIntosh	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	A	O	Forest	McIntosh	2001

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Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	**Monochamus**	**urussovii**	Abies, Larix, Pivea, Pinus	Europe, Japan, China	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Prioninae	Prionus	pocularis		North America	A	O	Forest	Miller	2006
			Cerambycidae	Spondylinae	Arhopalus	rusticus nubilus		America	A	O	Forest	Milller	2006
			Cerambycidae	Spondylinae	Arhopalus	sp.			A	O	Forest	McIntosh	2001
			Cerambycidae	Spondylinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	McIntosh	2001
			Cerambycidae	Spondylidinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe,	A	M & O	Forest	Sweeney	2004
Monoterpenoid	(1S)-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-one 1S-verbenone	S-verbenone	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	K	Oviposition stimulant		Higgs	1978
Monoterpenoid	(1S)-3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene; S-3-carene	S-carene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	A	O	Forest	Fan	2007
			Cerambycidae	Lamiinae	**Monochamus**	**urussovii**	Abies, Larix, Pivea, Pinus	Europe, Japan, China	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	M & O	Forest	Sweeney	2004
Monoterpenoid	(1S)-6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; 1-S- beta pinene	S-beta-pinene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	A	O	Forest	Fan	2007
Monoterpenoid	(E)-3,7-Dimethyl-2,6-octadienal ; geranial	geranial	Cerambycidae	Cerambycinae	Megacyllene	caryae		Central & North America	P, Aggregation	male produced	Field & lab	Lacey	2008a
Monoterpenoid	(E)-(3,3-Dimethyl)-cyclohexylideneacetaldehyde; Grandlure IV	grandlureIV	Cerambycidae	Lamiinae	Dectes	texanus texanus		USA, Mexico	A		Forest	Patrick	1974
Monoterpenoid	(E)-3,7-Dimethyl-2,6-octadien-1-ol; geraniol	geraniol	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A		Olfactometer	Iwabuchi	1985
Monoterpenoid	(E)-6,10-Dimethyl-5,9-undecadien-2-ol; geranyl acetol	geranyl acetol	Cerambycidae	Spondylinae	Tetropium	cinnamopterum		North America	P	male produced	Forest	Silk	2007
			Cerambycidae	Spondylinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	P	male produced	Forest	Silk	2007
Monoterpenoid	(R)-1-Methyl-4-(1-methylethenyl)-cyclohexene; R-limonene	R-limonene	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	A	O		Fettköther	2000

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lamiinae	**Monochamus**	**urussovii**	Abies, Larix, Pivea, Pinus	Europe, Japan, China	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	M & O	Forest	Sweeney	2004
Monoterpenoid	(S)-1-Methyl-4-(1-methylethenyl)-cyclohexene ; S-limonene	S-limonene	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
			Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North America	P, Aggregation	male produced	Field	Lacey	2008a
Monoterpenoid	(Z)-3,7-Dimethyl-2,6-octadien-1-ol ; nerol	nerol	Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North America	P, Aggregation	male produced	Field	Lacey	2008a
Monoterpenoid	(Z)-3,7-Dimethyl-2,6-octadienal ; neral	neral	Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North America	P, Aggregation	male produced	Field	Lacey	2008a
Monoterpenoid	(Z)-(3,3-Dimethyl)-cyclohexylideneacetaldehyde; Grandlure III	grandlureIII	Cerambycidae	Lamiinae	Dectes	texanus texanus		USA, Mexico	A		Forest	Patrick	1974
Monoterpenoid	(Z)-2-(3,3-Dimethyl)-cyclohexylideneethanol ; Grandlure II	grandlureII	Cerambycidae	Lamiinae	Dectes	texanus texanus		USA, Mexico	A		Forest	Patrick	1974
Monoterpenoid	1-Isopropenyl-4-methylbenzene	P-cymenene	Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	EAG	Weißbecker	2006
Monoterpenoid	1-Isopropyl-4-methylbicyclo[3.1.0]hexan-3-ol ; Thujyl alcohol	Thyjyl alcohol	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
Monoterpenoid	1-Isopropyl-4-methylcyclohexa-1,3-diene ; Alpha terpinene	alpha-terpinene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
Monoterpenoid	1-Isopropyl-4-methyl-cyclohexa-1,4-diene ; Gamma terpinene	gamma-terpinene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	EAG	Weißbecker	2006

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
Monoterpenoid	1-Isopropyl-4-methylenebicyclo[3.1.0] hexane ; Sabinene	sabinene	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
Monoterpenoid	1-Methyl-4-(1-hydroxy-1-methylethyl)-benzene ; p-cymen-8-ol	p-cymenol	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	K			Higgs	1978
Monoterpenoid	1-Methyl-4-(1-methylethenyl)-cyclohexene ; Limonene	limonene	Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Asemum	striatum	P.Sylvestris	Asia, Europe, North America	A	O	Field	Chenier	1989
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
Monoterpenoid	1-Methyl-4-(1-methylethyl)-benzene ; p-cymene	p-cymene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	EAG	Weißbecker	2006
Monoterpenoid	1-Methyl-4-(1-methylethylidene)-cyclohexene ; Alpha terpinolene	alpha-terpinolene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
									A	O	Field	Fan	2007
			Cerambycidae	Lamiinae	**Monochamus**	**urussovii**	Abies, Larix, Pivea, Pinus	Europe, Japan, China	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al		Olfactometer	Yatagai	2002
			Scolytidae		Tomicus	destruens	Conifers		A	O	Olfactometer	Faccoli	2008
Monoterpenoid	2-(4-Methylcyclohex-3-enyl)-propan-2-ol; alpha terpineol	alpha-terpineol	Cerambycidae	Spondylidinae	Arhopalus	tristis		Europe, Middle East, North Africa, China	A	O	Olfactometer	Suckling	2001
			Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al		Olfactometer	Yatagai	2002
			Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North	P, Aggregation	male produced	Field	Lacey	2008a
Monoterpenoid	2,2-Dimethyl-3-methylenebicyclo[2.2.1] heptane; Camphene	Camphene	Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Field	Chenier	1989

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
Monoterpenoid	2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ; Alpha pinene	alpha-pinene	Cerambycidae	Cerambycinae	Neoclytus	muricatus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	longitarsus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	sagittatus	P. nigra	North America	A	O	Forest	Erbilgin	2003
			Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lamiinae	Acanthocinus	aedilis	Pinus spp.	Europe, Turkey, Eastern Asia	A		Forest	Schröder	1994
			Cerambycidae	Lamiinae	Acanthocinus	griseus	Pinus, Picea, Abies	Europe, Turkey	A	O	Forest	Fanfardi	2009
			Cerambycidae	Lamiinae	Acanthocinus	obliquus		North & Central America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	spectabilis		USA, Mexico	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lamiinae	**Monochamus**	**carolinensis**	P. banksiana; P. clausa; P. nigra; P. resinosa, P. strobus; P. sylvestris; P. ponderosa	North America	A	O	Forest	Erbilgin	2003
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Pajares	2004
									A	O	Forest	Ibeas	2007
									A	O	Forest	Fancardi	2009
									K	O	EAG	Weißbecker	2006
			Cerambycidae	Lamiinae	**Monochamus**	**mutator**	P. nigra; P resinosa	North America	K		Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**notatus**	P. strobus	North America	K		Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	K		Forest	De Groot	2004
			Cerambycidae	Lamiinae	Pogonocherus	pictus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Alosterna	tabacicolor		Europe, Turkey	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Lepturinae	Anastrangalia	chrysocoma		Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Pygoleptura	nigrella		North America	A	O	Forest	Costello	2008

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lepturinae	Stictoleptura	canadensis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	rubra	Picea, Pinus, Abies, Larix	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A	O	Forest	Costello	2008
			Cerambycidae	Prioninae	Tragosoma	depsarius	Pinus spp.; Picea abies	Europe, North america	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	ferus	Pinus spp.; Picea spp.	Europe, China, North Africa, Middle East	A			Brockerhoff	2006
			Cerambycidae	Spondylidinae	Arhopalus	productus	Pseudostuga menziesii	Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	syriacus	Pinus	Mideterranean	A	O	Forest	Fancardi	2009
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	cinnamopterum		North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	O	Olfactometer	Ikeda	1986
			Cerambycidae	Spondylidinae	Spondylis	upiformis		Central & North America	A	O	Forest	Costello	2008
			Scolytidae		Tomicus	destruens	Conifers		A	M & O	Olfactometer	Faccoli	2008
Monoterpenoid	2,6-Dimethyl-2,7-octadien-6-ol ; Linalool	Linalool	Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus		Japan	A	O	Olfactometer	Ikeda	1993
			Cerambycidae	Cerambycinae	Demonax	transilis		Japan	A	O	Olfactometer	Ikeda	1993
			Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A		Olfactometer	Iwabuchi	1985
Monoterpenoid	3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene ; 3-carene	3-carene	Cerambycidae	Cerambycinae	Neoclytus	muricatulus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	longitarsis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	obliquus		North & Central America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	spectabilis		USA, Mexico	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	EAG	Weißbecker	2006
			Cerambycidae	Lamiinae	Pogonocherus	pictus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Anastrangalia	sanguinea		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Cosmosalia	chrysocoma		Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Pygoleptura	nigrella		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	canadensis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Forest	Costello	2008

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A	O	Forest	Costello	2008
			Cerambycidae	Prioninae	Tragosoma	depsarius	Pinus spp.; Picea abies	Europe, North america	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	asperatus		America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	productus	Pseudostuga menziesii	Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	cinnamopterum		North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Spondylis	upiformis		Central & North America	A	O	Forest	Costello	2008
Monoterpenoid	4-Isopropyl-1-methylene-2-cyclohexene ; Beta_phellandrene	beta-phellandrene	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Spondulis	buprestoides	Conifers	Asia, Europe, North America	A	O		Ikeda	1986
Monoterpenoid	6,6-Dimethyl-2-methylenebicyclo[3.1.1] heptane; Beta pinene	beta-pinene	Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	O	Olfactometer	Ikeda	1986
Monoterpenoid	7-Methyl-3-methylene-1,6-octadiene ; Myrcene	Myrcene	Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	O	Field	Ikeda	1980
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	EAG	Weißbecker	2006
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Field	Chenier	1989
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	O		Ikeda	1986
			Scolytidae		Tomicus	destruens	Conifers		A	M & O	Olfactometer	Faccoli	2008
Monoterpenoid	Cis-2-Isopropenyl-1-methylcyclobutaneethanol ; Grandisol	grandisol	Cerambycidae	Lamiinae	Dectes	texanus texanus		USA, Mexico	A		Forest	Patrick	1974

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
Monoterpenoid	cis-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol	Cis-verbenol	Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Pajares	2004
									A	O	Forest	Fancardi	2009
			Cerambycidae	Lamiinae	Acanthocinus	griseus	Pinus, Picea, Abies	Europe, Turkey	A	O	Forest	Fancardi	2009
			Cerambycidae	Spondylidinae	Arhopalus	syriacus	Pinus	Mideterranean	A	O	Forest	Fancardi	2009
Sesquiterpenoids	(E,E)-1-Methyl-5-methylene-8-(1-methylethyl)-1,6-cyclodecadiene	Germacrene D	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	Al	O	olfactometer	Yamasaki	1997
Sesquiterpenoids	(E,E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene; E,E-alpha-farnesene	alpha-farnesene	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	K		Field & lab	Yasui	2007
Sesquiterpenoids	(E,E,E)-2,6,6,9-Tetramethyl-1,4,8-cycloundecatriene; Alpha-humelene	alpha-humelene	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	K		Field & lab	Yasui	2007
Sesquiterpenoids	(Z)-3,7,11-Trimethyl-1,6,10-dodecatrien-3-ol ; Cis-nerolidol	cis-nerolidol	Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al		olfactometer	Yatagai	2002
Sesquiterpenoids	(Z,E)-3,7-Dimethyl-2,6-octadienal ; citral	citral	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A	male produced	olfactometer	Iwabuchi	1985
Sesquiterpenoids	1,2,3,5,6,8a-Hexahydro-1-isopropyl-4,7-dimethylnaphthalene; Delta cadinene	delta-cadinene	Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al		olfactometer	Yatagai	2002
Sesquiterpenoids	1R-(1R*,4E,9S*)-4,11,11-Trimethyl-8-methylenebicyclo[7.2.0]undec-4-ene; Beta-caryophyllene	beta-caryophyllene	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	K		Field & lab	Yasui	2007
Sesquiterpenoids	2,4-Diisopropenyl-1-methyl-1-vinylcyclohexane ; Beta-elemene	beta-elemene	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	K		Field & lab	Yasui	2007
Sesquiterpenoids	2-(Decahydro-4a-methyl-1-methylenenaphthalen-7-yl)-propan-2-ol; Beta-eudesmol	beta-eudesmol	Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al	O	olfactometer	Yatagai	2002
Sesquiterpenoids	Cedrol	cedrol	Cerambycidae	Cerambycinae	Semanotus	japonicus		Japan, Canada	Al		olfactometer	Yatagai	2002
Sesquiterpenoids	Longiborneol; 1-R-	R-juniperol	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P.	Eastern Asia	K			Sakai	1990

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
	Juniperol						luchuensis; P. thunberghii		K	O	olfactometer	Yamasaki	1997
Diterpene	(1R)-Pimaral	pimaral	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K			Sakai	1990
									K	O	olfactometer	Yamasaki	1997
Turpentine	Turpentine	Turpentine	Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A		Field	Gardiner	1957
			Cerambycidae	Cerambycinae	Phymatodes	dimidiatus		North America	A		Field	Gardiner	1957
			Cerambycidae	Lamiinae	**Monochamus**	**carolinensis**	P. banksiana; P. clausa; P. nigra; P. resinosa, P. strobus; P. sylvestris; P. ponderosa	North America	A		Forest	Fatzinger	1987
									A		Forest	Philips	1988
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	K	O	Forest	Pajares	2004
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A		Forest	Fatzinger	1987
									A		Forest	Philips	1988
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America					
			Cerambycidae	Lamiinae	Pogonocherus	mixtus		North America	A		Field	Gardiner	1957
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A		Field	Gardiner	1957
			Cerambycidae	Lepturinae	Evodinus	monticola		North America	A		Field	Gardiner	1957
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A		Field	Gardiner	1957
			Cerambycidae	Lepturinae	Sachalinobia	undulatus		North America	A		Field	Gardiner	1957
			Cerambycidae	Spondylinae	Asemum	atrum		Asia, Europe, North America	A		Field	Gardiner	1957
			Cerambycidae	Spondylinae	Tetropium	cinnamopterum		North America	A		Field	Gardiner	1957

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
Others	(1R,4R,5R)-5-Hydroxy-4-[(E)-7-hydroxy-4-methylhept-3-enyl]4,8-dimethyl-3-oxabicyclo[3.3.0]octan-7-en-2,6-dione; Gomadalactone B	GomadalactoneB	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, contact		olfactometer	Yasui	2007a
	(1S,4R,5S)-5-Hydroxy-4-[(E)-7-hydroxy-4-methylhept-3-enyl]4,8-dimethyl-3-oxabicyclo[3.3.0]octan-7-en-2,6-dione; Gomadalactone A	GomadalactoneA	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, contact		olfactometer	Yasui	2007a
	(1S,4R,5S,8S)-5-Hydroxy-4-[(E)-7-hydroxy-4-methylhept-3-enyl]4,8-dimethyl-3-oxabicyclo[3.3.0]octan-2,6-dione; Gomadalactone C	GomadalactoneC	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, contact		olfactometer	Yasui	2007a
alcohol	(2R,3R)-2,3-Hexanediol	RRHexanediol	Cerambycidae	Cermabycinae	Curius	dentatus		USA	P, aggregation		Field & lab	Lacey	2004
			Cerambycidae	Cerambycinae	Neoclytus	acuminatus acuminatus	Fraxinus spp. Qnd other	Europe, America	P, aggregation	male produced	Field & lab	Lacey	2004
			Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	P, aggregation	male produced		Fettkother	1995
alcohol	(2R,3S)-2,3-Hexanediol	RSHexanediol	Cerambycidae	Cerambycinae	Curius	dentatus		USA	A		Field & lab	Lacey	2004
			Cerambycidae	Spondylinae	Megacyllene	caryae		Central & North America	P, aggregation	male produced	Field & lab	Lacey	2008a
	(2S)-2-Hydroxydecan-3-one	2-2-hydroxydecanone	Cerambycidae	Cerambycinae	Demonax	balyi			A		Field	Hall	2006
			Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P, aggregation	male produced	Field	Hall	2006
											Field	Rhainds	2001
											Field	Jayaram	1998
	(2S)-2-Hydroxyoctan-3-one	2-2-hydroxyoctanone	Cerambycidae	Cerambycinae	Xylotrechus	chinensis		Eastern Asia	P	male produced	olfactometer	Kuwahara	1987b
											olfactometer	Iwabuchi	1987
			Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	P	male produced	olfactometer	Iwabuchi	1986
											olfactometer	Iwabuchi	1985
											olfactometer	Sakai	1984
alcohol	(2S,3R)-2,3-Hexanediol	SRHexanediol	Cerambycidae	Cermabycinae	Curius	dentatus		USA	A		Field & lab	Lacey	2004
			Cerambycidae	Cerambycinae	Neoclytus	acuminatus acuminatus		Europe, America	P, aggregation	male produced	Field & lab	Lacey	2004
			Cerambycidae	Spondylinae	Megacyllene	caryae		Central & North America	P, aggregation	male produced	Field & lab	Lacey	2008a
alcohol	(2S,3S)-2,3-Hexanediol	SSHexanediol	Cerambycidae	Cermabycinae	Curius	dentatus		USA	P, aggregation	male produced	Field & lab	Lacey	2004
			Cerambycidae	Cerambycinae	Neoclytus	acuminatus acuminatus	Fraxinus spp. Qnd other	Europe, America	P, aggregation	male produced	Field & lab	Lacey	2004
alcohol	(2S,3S)-2,3-Octanediol	SSOctanediol	Cerambycidae	Cerambycinae	Xylotrechus	chinensis		Eastern Asia	P	male produced	olfactometer	Kuwahara	1987b
											olfactometer	Iwabuchi	1987
			Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	P	male produced	olfactometer	Iwabuchi	1986

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
											olfactometer	Iwabuchi	1985
											olfactometer	Sakai	1984
			Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P, aggregation	male produced	Field	Hall	2006
											Field	Rhainds	2001
												Jayaram	1998
	(3R)-3-Hydroxyhexan-2-one	3R-3-hydroxyhexanon	Cerambycidae	Cerambycinae	Phymatodes	lecontei		North America, Mexico	A		Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Brothylus	gemmulatus		USA	A		Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus		Japan	P	male produced		Nakamuta	1997
												Leal	1995b
			Cerambycidae	Cerambycinae	Neoclytus	modestus modestus		USA, Mexico	P, aggregation	male produced	Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Neoclytus	mucronatus mucronatus		USA	P, aggregation	male produced	Field & lab	Lacey	2007
			Cerambycidae	Cerambycinae	Sarosesthes	fulminans			P, aggregation	male produced	Field & lab	Lacey	2009
			Cerambycidae	Cerambycinae	Xylotrechus	colonus	Quercus spp, Caryae spp	North America	P, aggregation	male produced	Field & lab	Lacey	2009
			Cerambycidae	Cerambycinae	Xylotrechus	nauticus		USA, Mexico	P, aggregation	male produced	Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	P	male produced		Fettkother	1995
												Reffy	2005
	(3R)-3-Hydroxyoctan-2-one	3-3-hydroxyoctanone	Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus		Japan	P	male produced		Nakamuta	1997
												Leal	1995b
	(3S)-3-Hydroxyhexan-2-one	3S-3-hydroxyhexanon	Cerambycidae	Cerambycinae	Brothylus	gemmulatus		USA	A		Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Xylotrechus	colonus	Quercus spp, Caryae spp	North America	P, aggregation	male produced	Field & lab	Lacey	2009
			Cerambycidae	Cerambycinae	Xylotrechus	nauticus		USA, Mexico	P, aggregation	male produced	Forest	Hanks	2007
alcohol	(E)-2-Hexen-1-ol	E hexenol	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A			Iwabuchi	1985
aldehyde	(E)-2-Hexenal	E hexenal	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A			Iwabuchi	1985
alcohol	(R)-2-Methylbutan-1-ol	2Methylbutanol	Cerambycidae	Cerambycinae	Phymatodes	lecontei		North America & Mexico	P	male produced	Forest	Hanks	2007
	(Z)-18-Heptacosen-10-one	18Heptacosenone	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, conatct	female produced		Yasui	2003b
	(Z)-21-Methyl-8-pentatriacontene	21LMethylpentatriacon	Cerambycidae	Lamiinae	Psacothea	hilaris		Eastern Aisa	P, conatct	female produced		Fukaya	1996
alcohol	(Z)-3-Decen-1-ol	3Decenol	Cerambycidae	Cerambycinae	Rosalia	funebris	Alnus spp.; Quercus spp. Umbellaria spp.; Fraxinus spp.; Salix spp.	North America	P, Aggregation	male produced	Field	Ray	2009
	(Z)-3-Decenyl (E)-2-hexenoate	decenyl2hexanoate	Cerambycidae	Cerambycinae	Rosalia	funebris	Alnus spp.; Quercus spp. Umbellaria spp.; Fraxinus spp.; Salix spp.	North America	P, Aggregation	male produced	Field	Ray	2009

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
	(Z)-3-Decenyl (E)-3-hexenoate	decenyl3hexanoate	Cerambycidae	Cerambycinae	Rosalia	funebris	Alnus spp.; Quercus spp. Umbellaria spp.; Fraxinus spp.; Salix spp.	North America	P, Aggregation	male produced	Field	Ray	2009
	(Z)-3-Nonenyl (E)-2-hexenoate	Nonnenyl2hexanoate	Cerambycidae	Cerambycinae	Rosalia	funebris	Alnus spp.; Quercus spp. Umbellaria spp.; Fraxinus spp.; Salix spp.	North America	P, Aggregation	male produced	Field	Ray	2009
Alkene	(Z)-7-Heptacosene	7Heptacosene	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P, contact	female produced		Zhang	2003
Alkene	(Z)-7-Pentacosene	7pentacosene	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P, contact	female produced		Zhang	2003
Alkene	(Z)-9-Heptacosene	9Heptacosene	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P, contact	female produced		Zhang	2003
Alkene	(Z)-9-Nonacosene	9Nonacosene	Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North America	P, contact	female produced	olfactometer	Ginzel	2006
Alkene	(Z)-9-Pentacosene	9Pentacosene	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P, contact	female produced		Zhang	2003
			Cerambycidae	Spondylidinae	Megacyllene	robiniae		North America	P, contact	female produced	olfactometer	Ginzel	2003a
Alkene	(Z)-9-Tricosene	9Tricosene	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P, contact	female produced		Zhang	2003

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
	(Z,Z)-18,21-Heptacosadien-10-one	heptacosadienone	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, contact	female produced	olfactometer	Yasui	2003b
	(Z,Z,Z)-18,21,24-Heptacosatrien-10-one	heptacosatrienone	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P, contact	female produced	olfactometer	Yasui	2003b
Alcohol	(Z)-3-Hexen-1-ol	Z hexenol	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A	male produced	olfactometer	Iwabuchi	1985
			Cerambycidae		Arhopalus	tristis		Europe, Middle East, North Africa, China	A	O	olfactometer	Suckling	2001
			Scolytidae		Tomicus	destruens			A	M	olfactometer	Faccoli	2008
	10-Oxoisopiperitenone ;	vesperal	Cerambycidae	Vesperinae	Vesperus	xatarti		Europe	P			Boyer	1997
methylalkanes	15-Methylhentriacontane	methylhentriacontane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P		olfactometer	Fukaya	2000
methylalkanes	15-Methyltritriacontane	methyltritriacontane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P		olfactometer	Fukaya	2000
alcohol	1-Octen-3-ol	Octenol	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
	2-(1-methylethenyl-(1) benzopyrano (2,4-b) furo (2,3-h) (1)-benzopyran-6 (6H)-one	Rotenone	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	AI	deter oviposition	Field	Li	2005
	2,3-Decanedione	decanedione	Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced		Haal	2006
									P	male produced	Field	Rhainds	2001
alcohol	2,3-Octandiol	octandiol	Cerambycidae	Cerambycinae	Xylotrechus	chinensis		Eastern Asia	P	male produced		Kuwahara	1987b
alcohol	2-Ethylhexan-1-ol	ethylhexanol	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
	2-Hydroxydecan-3-one	2hydroxydecanone	Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced		Jayarama	1998
	2-Hydroxyhexan-3-one	2hydroxyhexanone	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	P	male produced		Fettkother	1995
	2-Hydroxyoctan-3-one	2hydroxyooctanone	Cerambycidae	Cerambycinae	Xylotrechus	chinensis		Eastern Asia	P	male produced		Kuwahara	1987b
			Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced	Field	Hall	2006
alcohol	2-Methyl-3-buten-1-ol	methylbutenol	Cerambycidae	Lamiinae	Acanthocinus	griseus	Pinus, Abies, Picea	Europe, Turkey	A	O	Forest	Fancardi	2009
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Ibeas	2007
									A	O	Forest	Pajares	2004
									A	O	Forest	Fancardi	2009
			Cerambycidae	Spondylidinae	Arhopalus	syriacus	Pinus	Mediterranean	A	O	Forest	Fancardi	2010
alcohol	2-Methylbutan-1-ol	methylbutanol	Cerambycidae	Cerambycinae	Phymatodes	decussatus decussatus		North America	A		Forest	Hanks	2007

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Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
aldehyde	2-Phenylacetaldehyde	phenylavetaldehyde	Cerambycidae	Lamiinae	Tetraopes	tetrophthalmus		North America	A			Theiss	2006
alcohol	2-Phenylethanol	phenylethanol	Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced	Field	Hall	2006
			Cerambycidae	Spondylidinae	Megacyllene	caryae		Central & North America	P, Aggregation	male produced	Field & lab	Lacey	2008a
	3,5-dimethyldodecanoic acid	dimethyldodecanoic acid	Cerambycidae	Prioninae	Prionus	californicus	Oaks, apple, cherry, almond	Central & North America	P	female produced		Rodstein	2009
	3-Hydroxydecan-2-one	3hydroxydecanone	Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced	Field	Hall	2006
	3-Hydroxyoctan-2-one	3hydroxyoctanone	Cerambycidae	Cerambycinae	Xylotrechus	chinensis		Eastern Asia	P	male produced		Kuwahara	1987B
	3-Methylpentacosane	3methypentacosane	Cerambycidae	Cerambycinae	Xylotrechus	colonus	Quercus spp, Caryae spp	North America	P, contact	female produced	olfactometer	Ginzel	2003b
alcohol	4-(Heptyloxy)-butan-1-ol	heptyloxybutanol	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P	male produced	EAG	Zhang	2002
									P	male produced	olfactometer	Nehme	2009
aldehyde	4-(Heptyloxy)-butanal	heptyloxybutanal	Cerambycidae	Lamiinae	Anoplophora	glabripennis	Acer spp.; Aesculus spp.; Fraxinus; Liriodendron spp.; Quercus rubra; Salix, Populus	Eastern Asia, France, Austria, USA	P	male produced	EAG	Zhang	2002
Phenol	4-Allyl-2-methoxyphenol ; Eugenol	eugenol	Cerambycidae	Cerambycinae	Xylotrechus	pyrrhoderus		Eastern Asia	A			Iwabuchi	1985
alkane	4-Methylhexacosane	4Methylhexacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P	female produced	olfactometer	Fukaya	2000
alkane	4-Methyloctacosane	4methyloctacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P	female produced	olfactometer	Fukaya	2000
alkane	7-Methylheptacosane	7Methylheptacosane	Cerambycidae	Cerambycinae	Neoclytus	acuminatus acuminatus	Deciduous trees	Europe, America	P, contact	female produced	olfactometer	Lacey	2008b
alkane	9-Methylheptacosane	9Methylheptacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P	female produced	olfactometer	Fukaya	2000
alkane	9-Methylnonacosane	9Methylnonacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P	female produced	olfactometer	Fukaya	2000
alkane	9-Methylpentacosane	9Methylpentacosane	Cerambycidae	Cerambycinae	Xylotrechus	colonus	Quercus spp, Caryae spp	North America	P, contact	female produced	olfactometer	Ginzel	2003b
	Benzyl acetate	Benzyl acetate	Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus		Japan	A	O	olfactometer	Ikeda	1993
			Cerambycidae	Cerambycinae	Demonax	transilis		Japan	A	O	olfactometer	Ikeda	1993
Alcohols	Butan-1-ol	Butanol	Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	P		Forest	Reddy	2005
									P	male produced		Fettkother	1995
Alcohols	Ethanol	ethanol	Cerambycidae	Cerambycinae	Elaphididionides	villosus			A	O	Forest	Montgomery	1983
			Cerambycidae	Cerambycinae	Ungleptes	querci			A	O	Forest	Montgomery	1983
			Cerambycidae	Cerambycinae	Clytus	ruricola		North America	A	O	Forest	Montgomery	1983

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Cerambycinae	Neoclytus	muricatulus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	sagittatus	P. nigra	North America	A		Forest	Fatzinger	1987
			Cerambycidae	Cerambycinae	Xylotrechus	sagittatus sagittatus		North America	A	O	Forest	Miller	2006
			Cerambycidae	Cerambycinae	Xylotrechus	undulatus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Cerambycinae	Elaphidion	mucronatum		North America	A		Forest	Dunn	1991
			Cerambycidae	Lamiinae	Acanthocinus	aedilis	Pinus spp.	Europe, Turkey, Eastern Asia	A			Schroeder	1994
			Cerambycidae	Lamiinae	Acanthocinus	nodosus		USA	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	Acanthocinus	obliquus		North & Central America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	obsoletus		North America	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	Acanthocinus	spectabilis		USA, Mexico	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**carolinensis**	P. banksiana; P. clausa; P. nigra; P. resinosa, P. strobus; P. sylvestris; P. ponderosa	North America	A		Forest	Fatzinger	1985
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Pajares	2004
									A	O	Forest	Ibeas	2007
									A	O	Forest	Fancardi	2009
			Cerambycidae	Lamiinae	**Monochamus**	**obtusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A		Forest	McIntosh	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	A		Forest	McIntosh	2001
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A	O	Forest	Miller	2006
			Cerambycidae	Lamiinae	Pogonocherus	pictus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Alosterna	tabacicolor		Europe, Turkey	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Lepturinae	Analeptura	lineada		North America	A			Montgomery	1983
			Cerambycidae	Lepturinae	Anastrangalia	sanguinea		North America	A	O	Forest	Costello	2008

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lepturinae	Cosmosalia	chrysocoma		Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Pygoleptura	nigrella		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	canadensis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	rubra	Picea, Pinus, Abies, Larix	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus proteus		North America	A	O	Field	Chenier	1989
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A	O	Forest	Costello	2008
			Cerambycidae	Prioninae	Tragosoma	depsarius	Pinus spp.; Picea abies	Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	asperatus		America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	ferus	Pinus spp.; Picea spp.	Europe, China, North Africa, Middle East	A			Brockerhoff	2006
			Cerambycidae	Spondylidinae	Arhopalus	productus	Pseudostuga menziesii	Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	rusticus nubilus		America	A	O	Forest	Miller	2006
			Cerambycidae	Spondylidinae	Arhopalus	rusticus obsoletus	P. sylvestris	America	A		Forest	Fatzinger	1987
			Cerambycidae	Spondylidinae	Arhopalus	sp.			A		Forest	McIntosh	2001
			Cerambycidae	Spondylidinae	Asemum	sp.			A		Forest	McIntosh	2001
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	castaneum	Picea spp.; Pinus spp.; Abies spp.	Europe, China, Japan	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Tetropium	cinnamopterum		North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	fuscum	Picea spp; Pinus spp.	Europe	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	buprestoides	Conifers	Asia, Europe, North America	A	M & O	Forest	Sweeney	2004
			Cerambycidae	Spondylidinae	Spondylis	upiformis		Central & North America	A	O	Forest	Costello	2008
	Flavonol glucoside: (-)-2,3-trans-dihydroquercetin-3'-o-beta-D-glucopyranoside	Flavonol glucoside	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	oviposition stimulant	olfactometer	Sato	1999
	Heptacosan-10-one	Heptacosan-10-one	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P		olfactometer	Yasui	2003b
	Heptacosan-12-one	Heptacosan-12-one	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P		olfactometer	Yasui	2003b
alkane	Heptacosane	Heptacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P		olfactometer	Fukaya	2000
alcohol	Hexan-1-ol	Hexanol	Cerambycidae	Cerambycinae	Xylotrechus	pyrroderus		North America	A		olfactometer	Iwabuchi	1985
			Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
	Hexane-2,3-dione	Hexane-2,3-dione	Cerambycidae	Cerambycinae	Neoclytus	modestus modestus		USA, Mexico	A		Forest	Hanks	2007
			Cerambycidae	Cerambycinae	Hylotrupes	bajulus	Pinus, Abies, Picea	Europe, Asia, North America, South Africa, Australia	P	male produced		Fettkother	1995
	Methyl 2-phenylacetate	MethylPhenylacetate	Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus	Cryptomeria	Japan	A		Field	Nakashima	1994
									P, Aggregation	male produced		Nakamuta	1997
	N-(2S)-Methylbutanoyl 2-methylbutylamine	N-(2S)-Methylbutanoyl 2-methylbutylamine	Cerambycidae	Anoplordermatina	Migdolus	fryanus		South America	P	female produced	Field	Leal	1994
	N-Formyl L-isoleucine methyl ester	N-Formyl L-isoleucine methyl ester	Cerambycidae	Anoplordermatina	Migdolus	fryanus		South America	P	female produced	Field	Leal	1994
alkane	Nonacosane	Nonacosane	Cerambycidae	Lamiinae	Anoplophora	malasiaca	Deciduous trees	Eastern Asia, France, Italy	P	female produced	olfactometer	Fukaya	2000
	Octanoic acid	Octanoic acid	Cerambycidae	Cerambycinae	Xylotrechus	quadripes		Eastern Asia	P	male produced	Field	Hall	2006
alcohol	Pentan-1-ol	pentanol	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A		EAG	Kong	2005
alkane	Pentacosane	pentacosane	Cerambycidae	Cerambycinae	Xylotrechus	colonus	Quercus spp, Caryae spp	North America	P, contact	female produced	olfactometer	Ginzel	2003b
	Phenylethyl propionate	Phenylethyl propionate	Cerambycidae	Cerambycinae	Anaglyptus	subfasciatus		Japan	A	O	olfactometer	Ikeda	1993
			Cerambycidae	Cerambycinae	Demonax	transilis		Japan	A	O	olfactometer	Ikeda	1993
	Procyanidin B-1: epicatechin-(4beta _8')-catechin	Procyanidin B-1	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	oviposition stimulant	olfactometer	Sato	1999
	Procyanidin B-3: catechin-(4alpha _8')-catechin	Procyanidin B-3	Cerambycidae	Lamiinae	**Monochamus**	**alternatus**	P. densiflora; P. luchuensis; P. thunberghii	Eastern Asia	K	oviposition stimulant	olfactometer	Sato	1999
Pheromones of bark beetle	1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane ; Frontalin	Frontalin	Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**mutator**	P. nigra; P resinosa	North America	K		Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**notatus**	P. strobus	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**obtusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	A	O	Forest	Allison	2001
Pheromones of	2-Hydroxy-4,4,6-	Lanierone	Cerambycidae	Cerambycinae	Xylotrechus	sagittatus	P. nigra	North America	A	O	Forest	Erbilgin	2003

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
bark beetle	trimethyl-2,5-cyclohexadien-1-one ; Lanierone		Cerambycidae	Lamiinae	**Monochamus**	**carolinensis**	P. banksiana; P. clausa; P. nigra; P. resinosa, P. strobus; P. sylvestris; P. ponderosa	North America	A	O	Forest	Erbilgin	2003
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A	O	Forest	Miller	2005
Pheromones of bark beetle	2-Methyl-6-methylene-2,7-octadien-4-ol ; Ipsedienol	Ipsedienol	Cerambycidae	Cerambycinae	Neoclytus	muricatulus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	longitarsis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	sagittatus	P. nigra	North America	A	O	Forest	Erbilgin	2003
			Cerambycidae	Lamiinae	Acanthocinus	obliquus		North & Central America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	spectabilis		USA & Mexico	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**carolinensis**	P. banksiana; P. clausa; P. nigra; P. resinosa, P. strobus; P. sylvestris; P. ponderosa	North America	A	O	Forest	Erbilgin	2003
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Pajares	2004
									A	O	Forest	Francardi	1999
			Cerambycidae	Lamiinae	**Monochamus**	**mutator**	P. nigra; P resinosa	North America	K		Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**notatus**	P. strobus	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**obtsusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	A	O	Forest	Allison	2001

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A	O	Forest	Miller	2005
			Cerambycidae	Lamiinae	Pogonocherus	pictus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Anastrangalia	sanguinea		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Cosmosalia	chrysocoma		Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Pygoleptura	nigrella		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	canadensis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A	O	Forest	Costello	2008
			Cerambycidae	Prioninae	Tragosoma	depsarius	Pinus spp.; Picea abies	Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	asperatus		America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	productus	Pseudostuga menziesii	Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	cinnamopterum		North America	A	O	Forest	Costello	2008
Pheromones of bark beetle	2-Methyl-6-methylene-7-octen-4-ol ; Ipsenol	Ipsenol	Cerambycidae	Cerambycinae	Neoclytus	muricatulus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Cerambycinae	Xylotrechus	longitarsis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	obliquus		North & Central America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	Acanthocinus	spectabilis		USA & Mexico	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
									A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**galloprovincialis**	P. pinaster; P.halepensis; P.insignis; P. nigra; P. pinaster; P. pinea; P. sylvestris; Picea abies	North Africa, France, Portugal, Spain	A	O	Forest	Ibeas	2007
									A	O	Forest	Pajares	2004
									A	O	Forest	Francardi	2009
			Cerambycidae	Lamiinae	**Monochamus**	**notatus**	P. strobus	North America	A	O	Forest	Allison	2001
									K	O	Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**obtusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P.	North America	A	O	Forest	Allison	2001
									A	O	Forest	De Groot	2004
			Cerambycidae	Lamiinae	**Monochamus**	**titillator**	P. strobus; P.sylvestris; P. thunbergii; Picea glauca	America	A	O	Forest	Miller	2005

Annex 1
Semiochemicals of Cerambycids

Group	Compound	Simplified Name	Family	Subfamily	Genus	Species	Host Plant	Continent	Activity	Period	Application	Reference	year
			Cerambycidae	Lamiinae	Pogonocherus	pictus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Anastrangalia	sanguinea		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Cosmosalia	chrysocoma		Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Pygoleptura	nigrella		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Stictoleptura	canadensis		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Acmaeops	proteus		North America	A	O	Forest	Costello	2008
			Cerambycidae	Lepturinae	Rhagium	inquisitor	polyphagous	Asia, Europe, Central & North America, North Africa	A	O	Forest	Costello	2008
			Cerambycidae	Prioninae	Tragosoma	depsarius	Pinus spp.; Picea abies	Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	asperatus		America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Arhopalus	productus	Pseudostuga menziesii	Central & North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Asemum	striatum	P. sylvestris	Asia, Europe, North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Tetropium	cinnamopterum		North America	A	O	Forest	Costello	2008
			Cerambycidae	Spondylidinae	Spondylis	upiformis		Central & North America	A	O	Forest	Costello	2008
Pheromones of bark beetle	3-Methyl-2-cyclohexen-1-ol ; seudenol	seudenol	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A	O	EAG	Kong	2005
Pheromones of bark beetle	3-Methyl-2-cyclohexen-1-one ; Sudenone	Sudenone	Cerambycidae	Cerambycinae	Semanotus	bifasciatus		China, Japan, Russia	A	O	EAG	Kong	2005
			Cerambycidae	Lamiinae	**Monochamus**	**clamator**	P. contorta	North America	A	O	Forest	Costello	2008
			Cerambycidae	Lamiinae	**Monochamus**	**notatus**	P. strobus	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**obtsusus**	Abies spp.; Pinus spp.; Pseudostuga spp.	North America	A	O	Forest	Allison	2001
			Cerambycidae	Lamiinae	**Monochamus**	**scutellatus**	P. banksiana; P. nigra; P.strobus; P. resinosa, P. virginiana, Abies balsamea; Larix lacinia	North America	A	O	Forest	Allison	2001

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1R-α-pinene	(1R,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-ol; Cis-3-pinen-2-ol	(1S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1S-alpha-pinene	(1S)-3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene; S-3-carene	(1S)-6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; 1-S- beta pinene	(R)-1-Methyl-4-(1-methylethenyl)-cyclohexene; R-limonene	1-Isopropenyl-4-methylbenzene	1-Isopropyl-4-methylcyclohexa-1,3-diene ; Alpha terpinene
					R-alpha-pinene	**pinenol**	**S-alpha-pinene**	**S-carene**	**S-beta-pinene**	**R-limonene**	**P-cymenene**	**Alpha terpinene**
Fan	2007	**Monochamus alternatus**	1	***	X							
			2	**	X							
			3	**	X							
			4	**	X							
			5	**	X(1)			X(1)	X(1)			
			6	**	X(1)			X(2)	X(2)			
			7	**	X(1)			X(4)	X(4)			
			8	*	X(2)			X(2)	X(1)			
			9	**	X(2)			X(4)	X(2)			
			10	**	X(2)			X(1)	X(4)			
			11	**	X(4)			X(4)	X(1)			
			12	**	X(4)			X(1)	X(2)			
			13	**	X(4)			X(2)	X(4)			
			14	***	X(1)			X(1)	X(1)			
Ikeda	1980	**Monochamus alternatus**	1	*						X(1)		X(0.1)
			2	**						X(1)		X(0.1)
			3	*						X(1.7)		X(0.2)
			4	***						X(1.7)		X(0.2)
Yamasaki	1997	**Monochamus alternatus**		***								
				***								
				***								
				*								
Li	2005	**Monochamus alternatus**	1	0								
Sato	1999	**Monochamus alternatus**	1	0								
			2	0								
			3	0								
			4	***								
Sakai	1991	**Monochamus alternatus**	only for male	***		X						
Erbilgin	2003	**Monochamus carolinensis**	1	**								
Philips	1988	**Monochamus carolinensis**	1	***								
			2	*								
			3	**								
Fatzinger	1987	**Monochamus carolinensis**	1	**								
Costello	2008	**Monochamus clamator**	1	**								
			2	***								
			3	***								
			4	***								
McIntosh	2001	**Monochamus clamator**	1	***			X					

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1R-α-pinene	(1R,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-ol; Cis-3-pinen-2-ol	(1S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1S-alpha-pinene	(1S)-3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene; S-3-carene	(1S)-6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; 1-S- beta pinene	(R)-1-Methyl-4-(1-methylethenyl)-cyclohexene; R-limonene	1-Isopropenyl-4-methylbenzene	1-Isopropyl-4-methylcyclohexa-1,3-diene ; Alpha terpinene
					R-alpha-pinene	**pinenol**	**S-alpha-pinene**	**S-carene**	**S-beta-pinene**	**R-limonene**	**P-cymenene**	**Alpha terpinene**
Miller	1990	**Monochamus clamator**	1	***								
Allison	2001	**Monochamus clamator**	1	*								
			2	*								
			3	***								
			4	**								
Weißbecker	2006	**Monochamus galloprovinc**	1	***							X	
	EAG		2	***								
			3	***								
			4	***								
			5	***								
			6	***								
Ibeas	2007	**Monochamus galloprovinc**	1	***								
			2	**								
			3	***								
			4	***								
			5	***								
			6	**								
			1	*								
			2	**								
			3	*								
			4	*								
			5	***								
			6	***								
			7	**								
			8	**								
			1	*								
			2	*								
			3	**								
			4	**								
			5	***								
			6	***								
			7	***								
			8	**								
			9	**								
			1	**								
			2	***								
			3	**								
			4	**								

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1R-α-pinene	(1R,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-ol; Cis-3-pinen-2-ol	(1S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1S-alpha-pinene	(1S)-3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene; S-3-carene	(1S)-6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; 1-S- beta pinene	(R)-1-Methyl-4-(1-methylethenyl)-cyclohexene; R-limonene	1-Isopropenyl-4-methylbenzene	1-Isopropyl-4-methylcyclohexa-1,3-diene ; Alpha terpinene
					R-alpha-pinene	**pinenol**	**S-alpha-pinene**	**S-carene**	**S-beta-pinene**	**R-limonene**	**P-cymenene**	**Alpha terpinene**
Pajares	2004	**Monochamus galloprovinc**	1	*								
			2	**								
			1	*								
			2	**								
			1	*								
			2	**								
			3	**								
			4	**								
			1	*								
			2	**								
			3	**								
			4	***								
Francardi	2009	**Monochamus galloprovinc**	1	***								
			2	**								
			3	***								
			4	**								
De Groot	2004	**Monochamus mutator**	1	***								
			2	***								
			3	***								
			4	**								
De Groot	2004	**Monochamus notatus**	1	***								
			2	***								
			3	**								
Allison	2001	**Monochamus notatus**	1	*	X		X		X			
			2	*	X		X		X			
			3	***	X		X		X			

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	(1R)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1R-α-pinene	(1R,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-ol; Cis-3-pinen-2-ol	(1S)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene; 1S-alpha-pinene	(1S)-3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene; S-3-carene	(1S)-6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; 1-S- beta pinene	(R)-1-Methyl-4-(1-methylethenyl)-cyclohexene; R-limonene	1-Isopropenyl-4-methylbenzene	1-Isopropyl-4-methylcyclohexa-1,3-diene ; Alpha terpinene
					R-alpha-pinene	**pinenol**	**S-alpha-pinene**	**S-carene**	**S-beta-pinene**	**R-limonene**	**P-cymenene**	**Alpha terpinene**
			4	**	X		X		X			
McIntosh	2001	**Monochamus obtsusus**	1	***			X					
Allison	2001	**Monochamus obtsusus**	1	*								
			2	*								
			3	***								
			4	**								
De Groot	2004	**Monochamus scutellatus**	1	***								
			2	**								
			3	**								
			4	**								
			5	**								
			1	**								
			2	**								
			3	**								
			4	**								
			5	**								
			6	***								
McIntosh	2001	**Monochamus scutellatus**	1	***			X					
Allison	2001	**Monochamus scutellatus**	1	***	X		X		X			
			2	***	X		X		X			
			3	***	X		X		X			
			4	***	X		X		X			
Miller	2005	**Monochamus titillator**	1	*								
			2	**								
			3	**								
			4	***								
			5	***								
			6	***								
			7	***								
Miller	2006	**Monochamus titillator**	1	*								
			2	**			X					
			3	***			X					
Fatzinger	1987	**Monochamus titillator**	1	**								
Sweeney	2004	**Monochamus urussovii**	1	**	X			X	X	X		
			2	*								
			3	**	X							
			4	***	X			X	X	X		
			5	**	X			X	X	X		

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	1-Isopropyl-4-methyl-cyclohexa-1,4-diene ; Gamma terpinene	1-Isopropyl-4-methylenebicyclo[3.1.0]hexane ; Sabinene	1-Methyl-4-(1-methylethyl)-benzene ; p-cymene	1-Methyl-4-(1-methylethylidene)-cyclohexene ; Alpha terpinolene	2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane; Camphene	2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ; Alpha pinene	3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene ; 3-carene	4-Isopropyl-1-methylene-2-cyclohexene ; Beta_phellandrene
					Gamma terpinene	**sabinene**	**p-cymene**	**Alpha terpinolene**	**Camphene**	**Alpha pinene**	**3-carene**	**Betta-phellandrene**
Fan	2007	**Monochamus alternatus**	1	***								
			2	**								
			3	**								
			4	**								
			5	**				X(1)				
			6	**				X(2)				
			7	**				X(4)				
			8	*				X(4)				
			9	**				X(1)				
			10	**				X(2)				
			11	**				X(2)				
			12	**				X(4)				
			13	**				X(1)				
			14	***				X(1)				
Ikeda	1980	**Monochamus alternatus**	1	*	X(0.1)	X(1)	X(0.1)	X(1)	X(2)	X(75)		
			2	**	X(0.1)	X(1)	X(0.1)	X(1)	X(2)	X(75)		
			3	*	X(0.2)	X(1)	X(0.2)	X(2.3)	X(1.3)	X(48.4)		
			4	***	X(0.2)	X(1)	X(0.2)	X(2.3)	X(1.3)	X(48.4)		
Yamasaki	1997	**Monochamus alternatus**		***								
				***								
				***								
				*								
Li	2005	**Monochamus alternatus**	1	0								
Sato	1999	**Monochamus alternatus**	1	0								
			2	0								
			3	0								
			4	***								
Sakai	1991	**Monochamus alternatus**	only for male	***								
Erbilgin	2003	**Monochamus carolinensis**	1	**						X		
Philips	1988	**Monochamus carolinensis**	1	***								
			2	*								
			3	**								
Fatzinger	1987	**Monochamus carolinensis**	1	**								
Costello	2008	**Monochamus clamator**	1	**						X		
			2	***						X	X	
			3	***						X		
			4	***						X		
McIntosh	2001	**Monochamus clamator**	1	***								

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	1-Isopropyl-4-methyl-cyclohexa-1,4-diene ; Gamma terpinene	1-Isopropyl-4-methylenebicyclo[3.1.0]hexane ; Sabinene	1-Methyl-4-(1-methylethyl)-benzene ; p-cymene	1-Methyl-4-(1-methylethylidene)-cyclohexene ; Alpha terpinolene	2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane; Camphene	2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ; Alpha pinene	3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene ; 3-carene	4-Isopropyl-1-methylene-2-cyclohexene ; Beta_phellandrene
					Gamma terpinene	**sabinene**	**p-cymene**	**Alpha terpinolene**	**Camphene**	**Alpha pinene**	**3-carene**	**Betta-phellandrene**
Miller	1990	**Monochamus clamator**	1	***								X
Allison	2001	**Monochamus clamator**	1	*						X		
			2	*						X		
			3	***						X		
			4	**						X		
Weißbecker	2006	**Monochamus galloprovinc**	1	***								
	EAG		2	***	X							
			3	***			X					
			4	***						X		
			5	***							X	
			6	***								
Ibeas	2007	**Monochamus galloprovinc**	1	***						X		
			2	**						X		
			3	***						X		
			4	***						X		
			5	***						X		
			6	**						X		
			1	*						X		
			2	**						X		
			3	*						X		
			4	*						X		
			5	***						X		
			6	***						X		
			7	**						X		
			8	**						X		
			1	*								
			2	*								
			3	**						X		
			4	**						X		
			5	***								
			6	***						X		
			7	***						X		
			8	**						X		
			9	**						X		
			1	**						X		
			2	***						X		
			3	**						X		
			4	**						X		

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	1-Isopropyl-4-methyl-cyclohexa-1,4-diene ; Gamma terpinene	1-Isopropyl-4-methylenebicyclo[3.1.0]hexane ; Sabinene	1-Methyl-4-(1-methylethyl)-benzene ; p-cymene	1-Methyl-4-(1-methylethylidene)-cyclohexene ; Alpha terpinolene	2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane; Camphene	2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ; Alpha pinene	3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene ; 3-carene	4-Isopropyl-1-methylene-2-cyclohexene ; Beta_phellandrene
					Gamma terpinene	**sabinene**	**p-cymene**	**Alpha terpinolene**	**Camphene**	**Alpha pinene**	**3-carene**	**Betta-phellandrene**
Pajares	2004	**Monochamus galloprovinc**	1	*								
			2	**								
			1	*						X		
			2	**						X		
			1	*								
			2	**								
			3	**								
			4	**								
			1	*						X		
			2	**								
			3	**						X		
			4	***						X		
Francardi	2009	**Monochamus galloprovinc**	1	***						X		
			2	**						X		
			3	***						X		
			4	**						X		
De Groot	2004	**Monochamus mutator**	1	***						X		
			2	***						X		
			3	***						X		
			4	**								
De Groot	2004	**Monochamus notatus**	1	***						X		
			2	***								
			3	**						X		
Allison	2001	**Monochamus notatus**	1	*	X			X			X	X
			2	*	X			X			X	X
			3	***	X			X			X	X

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	1-Isopropyl-4-methyl-cyclohexa-1,4-diene ; Gamma terpinene	1-Isopropyl-4-methylenebicyclo[3.1.0]hexane ; Sabinene	1-Methyl-4-(1-methylethyl)-benzene ; p-cymene	1-Methyl-4-(1-methylethylidene)-cyclohexene ; Alpha terpinolene	2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane; Camphene	2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ; Alpha pinene	3,7,7-Trimethylbicyclo[4.1.0]hept-3-ene ; 3-carene	4-Isopropyl-1-methylene-2-cyclohexene ; Beta_phellandrene
					Gamma terpinene	**sabinene**	**p-cymene**	**Alpha terpinolene**	**Camphene**	**Alpha pinene**	**3-carene**	**Betta-phellandrene**
			4	**	X			X			X	X
McIntosh	2001	**Monochamus obtsusus**	1	***								
Allison	2001	**Monochamus obtsusus**	1	*						X		
			2	*						X		
			3	***						X		
			4	**						X		
De Groot	2004	**Monochamus scutellatus**	1	***								
			2	**								
			3	**								
			4	**								
			5	**								
			1	**						X		
			2	**						X		
			3	**						X		
			4	**						X		
			5	**						X		
			6	***						X		
McIntosh	2001	**Monochamus scutellatus**	1	***								
Allison	2001	**Monochamus scutellatus**	1	***	X			X			X	X
			2	***	X			X			X	X
			3	***	X			X			X	X
			4	***	X			X			X	X
Miller	2005	**Monochamus titillator**	1	*								
			2	**								
			3	**								
			4	***								
			5	***								
			6	***								
			7	***								
Miller	2006	**Monochamus titillator**	1	*								
			2	**								
			3	***								
Fatzinger	1987	**Monochamus titillator**	1	**								
Sweeney	2004	**Monochamus urussovii**	1	**				X				
			2	*								
			3	**								
			4	***				X				
			5	**				X				

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; Beta pinene	7-Methyl-3-methylene-1,6-octadiene ; Myrcene	cis-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol		(E,E)-1-Methyl-5-methylene-8-(1-methylethyl)-1,6-cyclodecadiene	Longiborneol; 1-R- Juniperol	(1R)-Pimaral	Turpentine	2-(1-methylethenyl-(1) benzopyrano (2,4-b) furo (2,3-h) (1)-benzopyran-6 (6H)-one
					beta-pinene	**myrcene**	**Cis-verbenol**	**Verbenone**	**Germacrene D**	**R-juniperol**	**pimaral**	**turpentine**	**rotenone**
Fan	2007	**Monochamus alternatus**	1	***									
			2	**									
			3	**									
			4	**									
			5	**									
			6	**									
			7	**									
			8	*									
			9	**									
			10	**									
			11	**									
			12	**									
			13	**									
			14	***									
Ikeda	1980	**Monochamus alternatus**	1	*	X(10)	X(1)							
			2	**	X(10)	X(1)							
			3	*	X(10)	X(1.6)							
			4	***	X(10)	X(1.6)							
Yamasaki	1997	**Monochamus alternatus**		***						X			
				***							X		
				***						X	X		
				*					X	X	X		
Li	2005	**Monochamus alternatus**	1	0									X
Sato	1999	**Monochamus alternatus**	1	0									
			2	0									
			3	0									
			4	***									
Sakai	1991	**Monochamus alternatus**	only for male	***									
Erbilgin	2003	**Monochamus carolinensis**	1	**									
Philips	1988	**Monochamus carolinensis**	1	***								X	
			2	*									
			3	**								X	
Fatzinger	1987	**Monochamus carolinensis**	1	**			X					X	
Costello	2008	**Monochamus clamator**	1	**									
			2	***									
			3	***									
			4	***									
McIntosh	2001	**Monochamus clamator**	1	***									

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; Beta pinene	7-Methyl-3-methylene-1,6-octadiene ; Myrcene	cis-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol		(E,E)-1-Methyl-5-methylene-8-(1-methylethyl)-1,6-cyclodecadiene	Longiborneol; 1-R- Juniperol	(1R)-Pimaral	Turpentine	2-(1-methylethenyl-(1) benzopyrano (2,4-b) furo (2,3-h) (1)-benzopyran-6 (6H)-one
					beta-pinene	**myrcene**	**Cis-verbenol**	**Verbenone**	**Germacrene D**	**R-juniperol**	**pimaral**	**turpentine**	**rotenone**
Miller	1990	**Monochamus clamator**	1	***									
Allison	2001	**Monochamus clamator**	1	*									
			2	*			X	X					
			3	***									
			4	**			X	X					
Weißbecker	2006	**Monochamus galloprovinc**	1	***									
	EAG		2	***									
			3	***									
			4	***									
			5	***									
			6	***		X							
Ibeas	2007	**Monochamus galloprovinc**	1	***			X						
			2	**			X						
			3	***									
			4	***			X						
			5	***									
			6	**			X						
			1	*									
			2	**									
			3	*									
			4	*									
			5	***									
			6	***									
			7	**									
			8	**									
			1	*									
			2	*									
			3	**									
			4	**									
			5	***									
			6	***									
			7	***									
			8	**									
			9	**									
			1	**									
			2	***				X					
			3	**									
			4	**									

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; Beta pinene	7-Methyl-3-methylene-1,6-octadiene ; Myrcene	cis-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol		(E,E)-1-Methyl-5-methylene-8-(1-methylethyl)-1,6-cyclodecadiene	Longiborneol; 1-R- Juniperol	(1R)-Pimaral	Turpentine	2-(1-methylethenyl-(1) benzopyrano (2,4-b) furo (2,3-h) (1)-benzopyran-6 (6H)-one
					beta-pinene	**myrcene**	**Cis-verbenol**	**Verbenone**	**Germacrene D**	**R-juniperol**	**pimaral**	**turpentine**	**rotenone**
Pajares	2004	**Monochamus galloprovinc**	1	*								X	
			2	**			X					X	
			1	*									
			2	**									
			1	*								X	
			2	**								X	
			3	**								X	
			4	**			X					X	
			1	*									
			2	**									
			3	**									
			4	***			X						
Francardi	2009	**Monochamus galloprovinc**	1	***									
			2	**									
			3	***									
			4	**			X						
De Groot	2004	**Monochamus mutator**	1	***									
			2	***									
			3	***									
			4	**									
De Groot	2004	**Monochamus notatus**	1	***									
			2	***									
			3	**									
Allison	2001	**Monochamus notatus**	1	*		X							
			2	*		X	X	X					
			3	***		X							

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Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane; Beta pinene	7-Methyl-3-methylene-1,6-octadiene ; Myrcene	cis-4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol		(E,E)-1-Methyl-5-methylene-8-(1-methylethyl)-1,6-cyclodecadiene	Longiborneol; 1-R- Juniperol	(1R)-Pimaral	Turpentine	2-(1-methylethenyl-(1) benzopyrano (2,4-b) furo (2,3-h) (1)-benzopyran-6 (6H)-one
					beta-pinene	**myrcene**	**Cis-verbenol**	**Verbenone**	**Germacrene D**	**R-juniperol**	**pimaral**	**turpentine**	**rotenone**
			4	**		X	X	X					
McIntosh	2001	**Monochamus obtsusus**	1	***									
Allison	2001	**Monochamus obtsusus**	1	*									
			2	*			X	X					
			3	***									
			4	**			X	X					
De Groot	2004	**Monochamus scutellatus**	1	***									
			2	**									
			3	**									
			4	**			X						
			5	**									
			1	**									
			2	**									
			3	**									
			4	**			X						
			5	**									
			6	***									
McIntosh	2001	**Monochamus scutellatus**	1	***									
Allison	2001	**Monochamus scutellatus**	1	***		X							
			2	***		X	X	X					
			3	***		X							
			4	***		X	X	X					
Miller	2005	**Monochamus titillator**	1	*									
			2	**									
			3	**									
			4	***									
			5	***									
			6	***									
			7	***									
Miller	2006	**Monochamus titillator**	1	*									
			2	**									
			3	***									
Fatzinger	1987	**Monochamus titillator**	1	**			X					X	
Sweeney	2004	**Monochamus urussovii**	1	**		X							
			2	*									
			3	**									
			4	***		X							
			5	**		X							

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	2-Methyl-3-buten-1-ol	Ethanol	Flavonol glucoside: (-)-2,3-trans-dihydroquercetin-3'-o-beta-D-glucopyranoside	Methylcyclohexenone	Procyanidin B-1: epicatechin-(4beta _8')-catechin	Procyanidin B-3: catechin-(4alpha _8')-catechin	endo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane
					methylbutenol	**ethanol**	**Flavonol glucoside**	**Methylcyclohexenone**	**Procyanidin B-1**	**Procyanidin B-3**	**endo-brevicomin**
Fan	2007	**Monochamus alternatus**	1	***							
			2	**							
			3	**							
			4	**							
			5	**							
			6	**							
			7	**							
			8	*							
			9	**							
			10	**							
			11	**							
			12	**							
			13	**							
			14	***		X(1)					
Ikeda	1980	**Monochamus alternatus**	1	*							
			2	**		X(50%)					
			3	*							
			4	***		X(50%)					
Yamasaki	1997	**Monochamus alternatus**		***							
				***							
				***							
				*							
Li	2005	**Monochamus alternatus**	1	0							
Sato	1999	**Monochamus alternatus**	1	0			X				
			2	0					X		
			3	0						X	
			4	***			X		X	X	
Sakai	1991	**Monochamus alternatus**	only for male	***							
Erbilgin	2003	**Monochamus carolinensis**	1	**							
Philips	1988	**Monochamus carolinensis**	1	***							
			2	*		X					
			3	**		X					
Fatzinger	1987	**Monochamus carolinensis**	1	**		X					
Costello	2008	**Monochamus clamator**	1	**		X					
			2	***		X					
			3	***		X					
			4	***		X					
McIntosh	2001	**Monochamus clamator**	1	***		X					

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	2-Methyl-3-buten-1-ol	Ethanol	Flavonol glucoside: (-)-2,3-trans-dihydroquercetin-3'-o-beta-D-glucopyranoside	Methylcyclohexenone	Procyanidin B-1: epicatechin-(4beta _8')-catechin	Procyanidin B-3: catechin-(4alpha _8')-catechin	endo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane
					methylbutenol	**ethanol**	**Flavonol glucoside**	**Methylcyclohexenone**	**Procyanidin B-1**	**Procyanidin B-3**	**endo-brevicomin**
Miller	1990	**Monochamus clamator**	1	***							
Allison	2001	**Monochamus clamator**	1	*		X					
			2	*		X					X
			3	***		X		X			
			4	**		X		X			X
Weißbecker	2006	**Monochamus galloprovinc**	1	***							
	EAG		2	***							
			3	***							
			4	***							
			5	***							
			6	***							
Ibeas	2007	**Monochamus galloprovinc**	1	***	X	X					
			2	**		X					
			3	***	X	X					
			4	***	X	X					
			5	***	X	X					
			6	**		X					
			1	*							
			2	**							
			3	*							
			4	*	X						
			5	***	X						
			6	***	X	X					
			7	**	X						
			8	**	X	X					
			1	*							
			2	*		X					
			3	**							
			4	**		X					
			5	***	X						
			6	***	X						
			7	***	X	X					
			8	**							
			9	**		X					
			1	**	X						
			2	***	X						
			3	**	X			X			
			4	**	X						

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	2-Methyl-3-buten-1-ol	Ethanol	Flavonol glucoside: (-)-2,3-trans-dihydroquercetin-3'-o-beta-D-glucopyranoside	Methylcyclohexenone	Procyanidin B-1: epicatechin-(4beta _8')-catechin	Procyanidin B-3: catechin-(4alpha _8')-catechin	endo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane
					methylbutenol	**ethanol**	**Flavonol glucoside**	**Methylcyclohexenone**	**Procyanidin B-1**	**Procyanidin B-3**	**endo-brevicomin**
Pajares	2004	**Monochamus galloprovinc**	1	*		X					
			2	**	X	X					
			1	*		X					
			2	**	X	X					
			1	*		X					
			2	**		X					
			3	**		X					
			4	**	X	X					
			1	*		X					
			2	**							
			3	**		X					
			4	***	X	X					
Francardi	2009	**Monochamus galloprovinc**	1	***	X	X					
			2	**		X					
			3	***	X	X					
			4	**	X	X					
De Groot	2004	**Monochamus mutator**	1	***							
			2	***							
			3	***							
			4	**							
De Groot	2004	**Monochamus notatus**	1	***							
			2	***							
			3	**							
Allison	2001	**Monochamus notatus**	1	*		X					
			2	*		X					X
			3	***		X		X			

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	2-Methyl-3-buten-1-ol	Ethanol	Flavonol glucoside: (-)-2,3-trans-dihydroquercetin-3'-o-beta-D-glucopyranoside	Methylcyclohexenone	Procyanidin B-1: epicatechin-(4beta _8')-catechin	Procyanidin B-3: catechin-(4alpha _8')-catechin	endo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane
					methylbutenol	**ethanol**	**Flavonol glucoside**	**Methylcyclohexenone**	**Procyanidin B-1**	**Procyanidin B-3**	**endo-brevicomin**
			4	**		X		X			X
McIntosh	2001	**Monochamus obtsusus**	1	***		X					
Allison	2001	**Monochamus obtsusus**	1	*		X					
			2	*		X					X
			3	***		X		X			
			4	**		X		X			X
De Groot	2004	**Monochamus scutellatus**	1	***							
			2	**							
			3	**							
			4	**							
			5	**							
			1	**							
			2	**							
			3	**							
			4	**							
			5	**							
			6	***							
McIntosh	2001	**Monochamus scutellatus**	1	***		X					
Allison	2001	**Monochamus scutellatus**	1	***		X					
			2	***		X					X
			3	***		X		X			
			4	***		X		X			X
Miller	2005	**Monochamus titillator**	1	*							
			2	**							
			3	**							
			4	***							
			5	***							
			6	***							
			7	***							
Miller	2006	**Monochamus titillator**	1	*		X					
			2	**							
			3	***		X					
Fatzinger	1987	**Monochamus titillator**	1	**		X					
Sweeney	2004	**Monochamus urussovii**	1	**							
			2	*		X					
			3	**		X					
			4	***							
			5	**		X					

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	exo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane		1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane ; Frontalin	2-Hydroxy-4,4,6-trimethyl-2,5-cyclohexadien-1-one ; Lanierone	2-Methyl-6-methylene-2,7-octadien-4-ol ; Ipsedienol	2-Methyl-6-methylene-7-octen-4-ol ; Ipsenol	3-Methyl-2-cyclohexen-1-one ; Sudenone
					exo brevicomin	**trans-conopthorin**	**Frontaline**	**Lanierone**	**Ipsedienol**	**Ipsenol**	**Sudenone**
Fan	2007	**Monochamus alternatus**	1	***							
			2	**							
			3	**							
			4	**							
			5	**							
			6	**							
			7	**							
			8	*							
			9	**							
			10	**							
			11	**							
			12	**							
			13	**							
			14	***							
Ikeda	1980	**Monochamus alternatus**	1	*							
			2	**							
			3	*							
			4	***							
Yamasaki	1997	**Monochamus alternatus**		***							
				***							
				***							
				*							
Li	2005	**Monochamus alternatus**	1	0							
Sato	1999	**Monochamus alternatus**	1	0							
			2	0							
			3	0							
			4	***							
Sakai	1991	**Monochamus alternatus**	only for male	***							
Erbilgin	2003	**Monochamus carolinensis**	1	**				X	X		
Philips	1988	**Monochamus carolinensis**	1	***							
			2	*							
			3	**							
Fatzinger	1987	**Monochamus carolinensis**	1	**							
Costello	2008	**Monochamus clamator**	1	**							
			2	***							
			3	***						X	
			4	***					X		
McIntosh	2001	**Monochamus clamator**	1	***							

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	exo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane		1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane ; Frontalin	2-Hydroxy-4,4,6-trimethyl-2,5-cyclohexadien-1-one ; Lanierone	2-Methyl-6-methylene-2,7-octadien-4-ol ; Ipsedienol	2-Methyl-6-methylene-7-octen-4-ol ; Ipsenol	3-Methyl-2-cyclohexen-1-one ; Sudenone
					exo brevicomin	**trans-conopthorin**	**Frontaline**	**Lanierone**	**Ipsedienol**	**Ipsenol**	**Sudenone**
Miller	1990	**Monochamus clamator**	1	***							
Allison	2001	**Monochamus clamator**	1	*							
			2	*	X						
			3	***			X		X	X	
			4	**	X		X		X	X	
Weißbecker	2006	**Monochamus galloprovinc**	1	***							
	EAG		2	***							
			3	***							
			4	***							
			5	***							
			6	***							
Ibeas	2007	**Monochamus galloprovinc**	1	***					X	X	
			2	**					X	X	
			3	***					X	X	
			4	***					X		
			5	***					X		
			6	**					X		
			1	*							
			2	**						X	
			3	*					X		
			4	*							
			5	***						X	
			6	***						X	
			7	**					X		
			8	**					X		
			1	*						X	
			2	*						X	
			3	**						X	
			4	**						X	
			5	***						X	
			6	***						X	
			7	***						X	
			8	**					X	X	
			9	**					X	X	
			1	**						X	
			2	***						X	
			3	**						X	
			4	**		X				X	

Annex 2
Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	exo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane		1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane ; Frontalin	2-Hydroxy-4,4,6-trimethyl-2,5-cyclohexadien-1-one ; Lanierone	2-Methyl-6-methylene-2,7-octadien-4-ol ; Ipsedienol	2-Methyl-6-methylene-7-octen-4-ol ; Ipsenol	3-Methyl-2-cyclohexen-1-one ; Sudenone
					exo brevicomin	**trans-conopthorin**	**Frontaline**	**Lanierone**	**Ipsedienol**	**Ipsenol**	**Sudenone**
Pajares	2004	**Monochamus galloprovinc**	1	*							
			2	**					X		
			1	*							
			2	**					X	X	
			1	*							
			2	**						X	
			3	**					X	X	
			4	**					X		
			1	*							
			2	**						X	
			3	**						X	
			4	***					X	X	
Francardi	2009	**Monochamus galloprovinc**	1	***					X		
			2	**					X	X	
			3	***					X	X	
			4	**					X	X	
De Groot	2004	**Monochamus mutator**	1	***					X		
			2	***			X				
			3	***							
			4	**			X				
De Groot	2004	**Monochamus notatus**	1	***						X	
			2	***						X	
			3	**							
Allison	2001	**Monochamus notatus**	1	*							
			2	*	X						
			3	***			X		X	X	

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Semiochemicals of Monochamus

Reference	Year	Species	Mixture	Efficacy	exo-7-Ethyl-5-methyl-6,8-dioxabicyclo[3.2.1]octane		1,5-Dimethyl-6,8-dioxabicyclo[3.2.1]octane ; Frontalin	2-Hydroxy-4,4,6-trimethyl-2,5-cyclohexadien-1-one ; Lanierone	2-Methyl-6-methylene-2,7-octadien-4-ol ; Ipsedienol	2-Methyl-6-methylene-7-octen-4-ol ; Ipsenol	3-Methyl-2-cyclohexen-1-one ; Sudenone
					exo brevicomin	**trans-conopthorin**	**Frontaline**	**Lanierone**	**Ipsedienol**	**Ipsenol**	**Sudenone**
			4	**	X		X		X	X	
McIntosh	2001	**Monochamus obtsusus**	1	***							
Allison	2001	**Monochamus obtsusus**	1	*							
			2	*	X						
			3	***			X		X	X	
			4	**	X		X		X	X	
De Groot	2004	**Monochamus scutellatus**	1	***						X	
			2	**					X		
			3	**				X	X		
			4	**					X		
			5	**			X		X		
			1	**							
			2	**					X		
			3	**				X	X		
			4	**					X		
			5	**			X		X		
			6	***						X	
McIntosh	2001	**Monochamus scutellatus**	1	***							
Allison	2001	**Monochamus scutellatus**	1	***							
			2	***	X						
			3	***			X		X	X	
			4	***	X		X		X	X	
Miller	2005	**Monochamus titillator**	1	*				X			
			2	**					X		
			3	**				X	X		
			4	***						X	
			5	***				X		X	
			6	***					X	X	
			7	***				X	X	X	
Miller	2006	**Monochamus titillator**	1	*							
			2	**							
			3	***							
Fatzinger	1987	**Monochamus titillator**	1	**							
Sweeney	2004	**Monochamus urussovii**	1	**							
			2	*							
			3	**							
			4	***							
			5	**							