PART II

Profiles of selected forest pests

INSECT PESTS

Agrilus planipennis

Other scientific names: *Agrilus feretrius* Obenberger; *Agrilus marcopoli* Obenberger; *Agrilus marcopoli ulmi* Kurosawa
Order and Family: Coleoptera: Buprestidae
Common names: emerald ash borer; EAB

Agrilus planipennis Fairmaire, commonly known as the emerald ash borer, is a metallic wood-boring beetle that is a highly destructive pest of ash trees (*Fraxinus* spp.). This pest is native to eastern Asia and has been accidentally introduced into North America, presumably through infested wood-packaging materials from Asia, where it is a major threat to ash trees in forests, urban plantings and shelterbelts. It is responsible for the death and decline of millions of trees in Canada and the United States.

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Adult emerald ash borers, Agrilus planipennis

DISTRIBUTION

Native: Asia and the Pacific: Democratic People's Republic of Korea, Japan, Mongolia, People's Republic of China, Republic of Korea
Europe: Russian Federation
Introduced: North America: Canada (2002), United States (2002)

IDENTIFICATION

Adult beetles are metallic blue-green, slender, elongate, hairless and approximately 7.5 to 14 mm long and 3.1 to 3.4 mm wide (Kimoto and Duthie-Holt, 2006; McCullough and Katovich, 2004). The head is flat with a shield-shaped top and the kidney-shaped eyes are bronze or black. The prothorax, the segment behind the head which contains the first pair of legs, is slightly wider than the head and transversely rectangular,

but is the same width as the base of the wing covers (Kimoto and Duthie-Holt, 2006; McCullough and Katovich, 2004). Males are smaller than females and are further distinguished by the presence of fine hairs on the ventral side of the thorax (McCullough and Katovich, 2004).

Mature larvae are white to cream-coloured, 26 to 32 mm long with broad flattened bodies (Kimoto and Duthie-Holt, 2006; McCullough and Katovich, 2004). The head is relatively small, brown and retracted inside the enlarged prothorax (Haack *et al*., 2002). The abdomen is 10-segmented, some with bell-shaped posterior ends. The first eight segments have one pair of spiracles each and the last segment has one pair of brownish, pincer-like appendages.

HOSTS

In its native distribution, hosts include *Fraxinus* species (*F. chinensis*, *F. japonica*, *F. lanuginosa*, *F. mandshurica*, *F. mandshurica* var. *japonica*, *F. rhynchophylla*); *Juglans* spp. (*J. mandshurica*, *J. mandshurica* var. *sieboldiana*); *Pterocarya* spp. (*P. rhoifolia*); and *Ulmus* spp. (*U. davidiana*, *U. davidiana* var. *japonica*, *U. propinqua*) (McCullough and Katovich, 2004; EPPO, 2005). In its introduced range in North America, only *Fraxinus* species (*F. americana*, *F. nigra*, *F. pennsylvanica*) have been attacked (Kimoto and Duthie-Holt, 2006).

BIOLOGY

The emerald ash borer typically has a one-year life cycle although in colder regions it could require up to two years to complete a generation (McCullough and Katovich, 2004). The length of the life cycle is also influenced by the age of the infestation, the health of host tree, and other biotic and abiotic factors (Bauer *et al*., 2007). Immature beetles maturation feed on the leaves of host trees, creating irregular notches in the leaves (Kimoto and Duthie-Holt, 2006). Females can mate multiple times and egg-laying begins a few days after the initial mating. Egg-laying peaks toward the end of June, but eggs are laid throughout the summer and into the fall due to a prolonged adult emergence period and long adult longevity (Bauer *et al*., 2007). Females can lay 60 to 90 eggs in their lifetime and they deposit them singly in bark crevices on the main trunk or branches (greater than 2.5 cm diameter) in the crown (Kimoto and Duthie-Holt, 2006; McCullough and Katovich, 2004).

Eggs hatch within 7 to 10 days after which first instar larvae bore through the bark until they reach the phloem where they continue feeding through four larval stages (Bauer *et al*., 2007). Flat and wide 'S-shaped' galleries are created that are filled with a fine brownish frass. Galleries are typically 9 to 16 cm long, but can reach lengths of 20 to 30 cm, and increase in width as the larva grows (Kimoto and Duthie-Holt, 2006; McCullough and Katovich, 2004).


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Agrilus planipennis *larval galleries and adult exit holes*

Pupation occurs during the spring or summer and takes place at the end of a gallery either just beneath the bark near the surface of the sapwood (5 to 10 mm) or in the corky tissue of thick-barked trees (Kimoto and Duthie-Holt, 2006). Adult beetles emerge through small, distinct 'D-shaped' exit holes which are 3 to 4 mm in diameter. Emergence typically begins in late May and peaks in June (Bauer et al., 2007).

SYMPTOMS AND DAMAGE

In China, *A. planipennis* typically attacks ash trees in open areas or along forest edges while in North America it has infested ash trees in both open settings and closed forests (Haack *et al*., 2002). Attacks are initiated along the upper trunk and lower portions of the main branches with the lower trunk being the target in successive attacks (Haack *et al*., 2002). The borers are known to attack and kill trees of various sizes and conditions from small to large mature trees.

Trees attacked by the emerald ash borer are ultimately killed, typically within three years of the initial attack although under heavy infestations, trees can be killed within 1 to 2 years (Haack *et al*., 2002). This pest kills trees by feeding under the bark and disrupting the flow of nutrients and water throughout the tree (CFS, 2006a).

Symptoms of attack include frass-filled larval galleries in the cambium, adult exit holes, yellowing and thinning of foliage, dying of branches, dieback and mortality of the host tree. In response to larval feeding, callus tissue may be produced by the tree and may cause vertical bark cracks to occur over a gallery (Kimoto and Duthie-Holt, 2006). Woodpecker activity may also indicate the presence of this pest.

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Tree infested by Agrilus planipennis *exhibiting root sprouts and crown dieback*

DISPERSAL AND INTRODUCTION PATHWAYS

Adult emerald ash borers are strong fliers, typically in 8 to 12 m bursts, and have been known to fly over 1 km in search of suitable host material (Haack *et al*., 2002). Their relatively small size also subjects them to dispersal by air currents. Long distance spread, however, is primarily human assisted through the international trade and transport of plants, wood and wood products containing bark.

CONTROL MEASURES

No effective control methods are currently available although research is ongoing to investigate the biology of the pest, develop methods for early detection and evaluate possible control measures such as insecticides and natural enemies. Three hymenopteran parasitoids have been discovered in China that are considered suitable for use as biocontrol agents in North America including a larval ectoparasitoid *Spathius agrili*, a larval endoparasitoid *Tetrastichus planipennisi*, and a solitary, parthenogenic egg parasitoid *Oobius agrili* (Bauer *et al*., 2007). After consultations with scientists and land managers at federal and state agencies, university faculty members and the public, it was agreed that these parasitoids would be released at selected sites in Michigan, United States. Field releases of *O. agrili* and *T. planipennisi* began in July 2007 and releases of *S. agrili* were expected to begin in late summer or early fall (Bauer *et al*., 2007).

A. planipennis is classed as a quarantine pest in Canada and the United States and appears on the NAPPO alert list. Domestic phytosanitary measures have been imposed to restrict the movement of wood and wood products from infested to non-infested areas (Haack *et al*., 2002; CFS, 2006a). Regulated materials include: nursery stock; trees; logs; wood; rough lumber including pallets and other wood packaging materials; bark; wood chips or bark chips from ash (*Fraxinus* species); and firewood of all host tree species (CFIA, 2007). Canada and the United States are working together on strategies to combat the spread of this pest.

In 2002 the emerald ash borer was added to the EPPO A2 action list, and it has been recommended that EPPO member countries regulate it as a quarantine pest. Suggested phytosanitary measures for commodities of *Fraxinus* include origin from a pest-free area or heat treatment for wood and bark.

Anoplophora glabripennis

Other scientific names: *Anoplophora nobilis*; *Cerosterna glabripennis*; *Cerosterna laevigator*; *Melanauster nobilis*; *Melanauster luteonotatus*; *Melanauster angustatus*; *Melanauster nanakineus*
Order and Family: Coleoptera: Cerambycidae
Common names: Asian longhorned beetle; ALB; starry sky beetle; Basicosta white-spotted longicorn beetle

Anoplophora glabripennis Motschulsky, 1853 is a wood-boring beetle that is a major threat to broadleaved trees in both urban environments and naturally regenerated and planted forests. Native to China and Korea, it has been introduced into Europe and North America through international trade on wood packaging materials. As a result, many countries in other continents are increasingly concerned about this pest and have established phytosanitary restrictions for wooden packing materials from infested countries.


G. ALLARD


G. ALLARD

Asian longhorned beetles, China

DISTRIBUTION

Native: Asia and the Pacific: Democratic People's Republic of Korea, Japan, People's Democratic Republic of China, Republic of Korea (several records but no recent collections are known).
Introduced: North America: Introduced and under eradication in Canada (2003) and the United States (first introduced in 1990s, discovered in 1996).
Europe: Introduced but not established in Germany (Bayern), France (Gien, Sainte Anne sur Brivet, 2003), and Austria (Braunau, 2001), Poland (single specimen in 2003).

IDENTIFICATION

Typical adult Asian longhorned beetles are large (20 to 35 mm in length, 7 to 12 mm wide), shiny, and bluish-black in colour with white spots (Kimoto and Duthie-Holt, 2006). There is one prominent spine on each side of the black thorax. The antennae are black, spotted and very long; 2.5 times the body length in males and 1.3 times the body length in females (EPPO, 1999). The antennae have 11 segments, each with a white or whitish-blue base (Kimoto and Duthie-Holt, 2006). Legs are black with a bluish tinge. The *A. nobilis* form has yellow spots and is believed by some authorities to be a different species and by others as a different morphotype of a single species (Lingafelter and Hoebeke, 2002).

Larvae are legless creamy white grubs with a chitinized brown mark on the prothorax and when mature are up to 50 mm in length (EPPO, 1999; Kimoto and Duthie-Holt, 2006). The larvae and pupae are normally found inside the tree within the larval tunnels.

Eggs are off-white, oblong, approximately 5 to 7 mm in length with slightly concave ends (EPPO, 1999). They turn a yellowish-brown colour just before hatching.

HOSTS

In China, the major hosts are species and hybrids of the genus *Populus* including *P. nigra*, *P. deltoides*, *P.* x *canadensis* and the Chinese hybrid *P. dakhuanensis* (EPPO, 1999). *Salix* species, such as *S. babylonica* and *S. matsudana*, are also major hosts. Other hosts recorded in China include *Acer*, *Alnus*, *Malus*, *Melia*, *Morus*, *Platanus*, *Prunus*, *Pyrus*, *Robinia*, *Rosa*, *Sophora* and *Ulmus* species.

In North America, species of *Acer*, *Aesculus*, *Albizia*, *Betula*, *Celtis*, *Platanus*, *Populus*, *Salix*, *Sorbus* and *Ulmus* are known hosts (Kimoto and Duthie-Holt, 2006). The suitability of *Alnus*, *Crataegus*, *Elaeagnus*, *Fraxinus*, *Hibiscus*, *Malus*, *Morus*, *Prunus*, *Pyrus*, *Quercus*, *Robinia* and *Tilia* species in North America is still in question.

BIOLOGY

The life cycle of A. glabripennis is long but uneven, fecundity is high and there may be one or two generations per year (Pan, 2005). Adults may mate several times. Females chew oval oviposition slots (about 10 mm wide) and lay a single egg in the inner bark of the trunk, branches as small as 2 to 3 cm in diameter or exposed roots; exit holes left by emerging adults may also be used (Kimoto and Duthie-Holt, 2006; Pan, 2005). Frothy, white sap may exude from recently created oviposition niches which ferments and stains the bark over time.

Eggs hatch after approximately two weeks and larvae bore large galleries deep into the wood. Immature larvae feed on the inner bark and sapwood while mature larvae feed on the heartwood. Several larval tunnels may occur in the trunk which degrades the quality of timber and can even cause death of host trees (Pan, 2005). This beetle is able to survive and finish development in cut logs although females do not oviposit on dead, debarked wood. Adults emerge from host trees by chewing round exit holes, approximately 6 to 12 mm in diameter, and expelling large, coarse wood fibres on the ground (Kimoto and Duthie-Holt, 2006).


G. ALLARD


G. ALLARD


G. ALLARD

Damage caused by the Asian longhorned beetle, China

SYMPTOMS AND DAMAGE

Asian longhorned beetles are wood-borers that attack healthy and stressed trees. Adults feed on the leaves, petioles and twigs of host trees; feeding damage on young shoots causes them to wither and die (Kimoto and Duthie-Holt, 2006). Larval tunnels disrupt the vascular functioning of the host tree eventually weakening it to the point of death. Several generations can develop in one tree, causing severe damage.

Leaf yellowing and wilting, premature leaf drop, branch dieback and tree death are symptoms of advanced infestations of *A. glabripennis*. Infestations decrease diameter at breast height (DBH), tree height, timber volume, and biomass; these losses increase with forest age and pest density (Weilun and Wen, 2005).

According to experiments carried out in China, 4- to 10-year-old poplars die after 2 to 4 years of consecutive damage, and poplar forests grown in monoculture can die after 3 to 5 years of consecutive damage (Pan, 2005). Within 5 to 8 years, severe damage may occur depending on the host tree species, forest structure and growing status.

DISPERSAL AND INTRODUCTION PATHWAYS

The Asian longhorned beetle has a low dispersal rate. While adults are capable of flying 1 000 to 1 200 m per flight, short-distance flight is typical and they usually fly only 50 to 75 m in search of suitable hosts. Infestations spread slowly, reported as less than 300 m per year in Beijing poplar groves (Cavey, 2000).

The presence of preadult stages is usually not easily detectable hence eggs, larvae or pupae are readily dispersed in infested timber such as solid timber packaging and dunnage.

CONTROL MEASURES

Effective monitoring, quarantine and control of *A. glabripennis* are difficult since the adult stage can be short and detecting the early stages of damage during the concealed larval stages nearly impossible (Pan, 2005). Once *A. glabripennis* has infested a tree, the only treatment is to cut down, chip and burn the infested tree. In North America, eradication measures have been, and continue to be, carried out involving the removal of infested trees which has been successful in containing the spread of the beetle. Research aimed at providing technology to better detect, control and ultimately eradicate the pest from the region is ongoing.

In China, a variety of techniques have been investigated to control the pest including afforestation models, altering shelterbelt structure and composition, bait tree arrangement and treatment technology, application of synthetic pheromones, development of genetically modified poplars with resistance to pests, establishment of an eco-control system, and biocontrol applications such as the use of the parasitoid *Dastarcus helophorides* and woodpeckers (Weilun and Wen, 2005).

The establishment of the Asian longhorned beetle outside its native distribution has caused great concerns in many countries and is one of the invasive alien species that has led to the development of an international standard (ISPM No. 15) for the movement of wood packaging material that is treated to avoid phytosanitary risk.

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Control measures for the Asian longhorned beetle: insecticide impregnated sticks placed into the holes created by newly emerged larvae, China

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Removal and chipping of infested trees, Chicago, United States

Cinara cupressivora

Order and Family: Hemiptera: Aphididae
Common names: giant cypress aphid; cypress aphid

Cinara cupressivora Watson & Voegtlin, 1999 is a significant pest of Cupressaceae species and has caused serious damage to naturally regenerated and planted forests in Africa, Europe, Latin America and the Caribbean and the Near East. It is believed to have originated on *Cupressus sempervirens* from eastern Greece to just south of the Caspian Sea (Watson *et al.*, 1999). This pest has been recognized as a separate species for only a short time (Watson *et al.*, 1999) and much of the information on its biology and ecology has been reported under the name *Cinara cupressi*.


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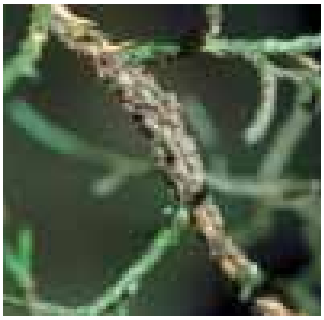
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Cypress aphids

DISTRIBUTION

Native: Europe and the Near East: eastern Greece to Islamic Republic of Iran
Introduced: Africa: Burundi (1988), Democratic Republic of Congo, Ethiopia (2004), Kenya (1990), Malawi (1986), Mauritius (1999), Morocco, Rwanda (1989), South Africa (1993), Uganda (1989), United Republic of Tanzania (1988), Zambia (1985), Zimbabwe (1989)
Europe: France, Italy, Spain, United Kingdom
Latin America and Caribbean: Chile (2003), Colombia
Near East: Jordan, the Syrian Arab Republic, Turkey, Yemen

IDENTIFICATION

Giant conifer aphid adults are typically 2 to 5 mm in length, dark brown in colour with long legs (Ciesla, 2003a). Their bodies are sometimes covered with a powdery wax. They typically occur in colonies of 20 to 80 adults and nymphs on the branches of host trees (Ciesla, 1991). Winged and non-winged adults can be found in the same colony.

Detailed descriptions of female adults are provided by Watson *et al.* (1999).

HOSTS

Austrocedrus chilensis; Callitris spp.; *Chamaecyparis* spp.; *Cupressus* spp., including *C. lusitanica*; *Juniperus* spp., including *J. bermudiana*; *Thuja* spp.; *Cupressocyparis* spp.; *Widdringtonia* spp., including *W. nodiflora*

Cinara cupressivora has a broad host range and would probably find any Cupressaceae species to be suitable host material (Ciesla, 2003a).

BIOLOGY

Cinara cupressivora has a high reproductive potential. Only females are present during the summer months which reproduce parthenogenetically and give birth to live young (Ciesla, 2003a). As cool weather approaches, both males and females are found and eggs are produced instead of live nymphs. Eggs are deposited in rough areas on twigs and foliage where they overwinter. Several generations are produced in a year and the life span of a single generation is about 25 days during the peak of the summer season (Ciesla, 2003a).


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Damage caused by the cypress aphid, Kenya

SYMPTOMS AND DAMAGE

Adults and nymphs suck the plant sap on terminal growth of young and old trees (Ciesla, 1991). Feeding retards new growth and causes desiccation of the stems and a progressive dieback on heavily infested trees. Damage to host trees includes browning and defoliation which, in some cases, causes dieback and death of trees. A secondary problem caused by aphid feeding is the copious quantities of honeydew which encourages the growth of sooty mould (Ciesla, 1991). The mould causes foliage discolouration and interferes with photosynthesis and gas exchange.

The occurrence of adult and larval coccinellids is often an indicator of aphid infestation as is the presence of ants, which tend the aphids and feed on the honeydew.

DISPERSAL AND INTRODUCTION PATHWAYS

Winged adults are capable of flying short distances although this is not considered an important means of spread. Adults and nymphs can be spread from tree to tree by air currents. Ants have developed a symbiotic relationship with *Cinara* aphids and are known to move aphids to new hosts to maintain colonies capable of producing copious amounts of honeydew on which the ants feed (Ciesla, 2003a).

This insect's present widespread worldwide distribution suggests that it is easily transported on live plant materials. Extensive planting of conifers that are hosts for *Cinara* species and international transport of nursery stock are the primary human assisted means of spread of conifer aphids.

CONTROL MEASURES

Cultural and biological control tactics are available for management of damaging populations of *Cinara cupressivora*. Short-term protection of cypress hedges and small ornamental trees has been achieved with ground applications of chemical pesticides but this is not recommended. In Africa, observations indicate that cypress plantations established on good soils are more tolerant of aphid infestations than those established on shallow, rocky soils and young, fast-growing plantations are less susceptible to damage than mature plantations (Ciesla, 2003a). Based on these observations, proper site selection and timely harvesting of plantations should reduce losses.

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Release of Pauesia *parasitoids for biocontrol of cypress aphid, western Kenya*

Biological control agents have been used successfully against several species of *Cinara*. The introduction of *Pauesia* spp. in Kenya and Malawi has significantly reduced the impact and spread of *C. cupressivora* (Day *et al.*, 2003). Larvae and adults of ladybird beetles and larvae of several species of syrphid flies (Diptera: Syrphidae) are natural control agents of the cypress aphid but they are not considered capable of controlling high populations (Ciesla, 2003a).

Cinara pinivora

Order and Family: Hemiptera: Aphididae
Common names: giant conifer aphid

Cinara pinivora Wilson, 1919 is sap-sucking aphid native to North America that has been introduced into Africa, Asia and the Pacific and Latin America and the Caribbean. A major pest of *Pinus* species, this aphid poses a significant threat to planted pine forests worldwide.


A. BALDINI


A. BALDINI

Cinara pinivora

DISTRIBUTION

Native: North America
Introduced: Africa: Kenya, Malawi
Asia and the Pacific: Australia
Latin America and the Caribbean: Argentina, Brazil (1996), Uruguay

IDENTIFICATION

The adult body length is typically 3.3 to 4.2 mm. The wingless form (apterae) have a shiny dark brown head, lighter brown thorax and abdomen with dark dorsal sclerites and spots of grey wax, and black steep-sided siphuncular cones. Legs have pale yellow sections. They are found in dense colonies at tips of branches, or scattered along older sections of twigs (Blackman and Eastop, 1994).

HOSTS

Pinus spp., including *P. elliottii* and *P. taeda*

BIOLOGY

A sap-sucking aphid, *Cinara pinivora* has a very short life cycle and is capable of multiplying rapidly. Some forms reproduce asexually at times and can therefore quickly build up numbers. Populations are extremely reduced during periods of high temperatures (Lázzari, Trentini and de Carvalho, 2004).

SYMPTOMS AND DAMAGE

Cinara pinivora forms dense colonies on all parts of host trees. It attacks young plantations of *Pinus* spp. infesting month old plants through to 3- to 4-year-old saplings and the tips of older plants. Damage starts as discolouration and premature needle fall with some branches turning brown. Inflammation of branches and mortality of plants has been observed in Brazil (Patti and Fox, 1981). The reduced photosynthetic surfaces results in stunting, affecting the form of host trees and reducing increments. A secondary problem caused by aphid feeding is the production of copious quantities of honeydew which encourages sooty mould growth.

DISPERSAL AND INTRODUCTION PATHWAYS

Winged adults are weak fliers, but are readily carried by wind over considerable distances. As adults or juveniles, they do not survive off host plant material for very long. Therefore, international transport of nursery stock is a significant pathway for the introduction of *C. pinivora*.

CONTROL MEASURES

According to Penteado (1995), biological control has been achieved in Brazil through the release of insect predators of the families Coccinellidae, Syrphidae, Chrysophidae, Staphilidae, Dermaptera and some Heteroptera.

Dendroctonus frontalis

Other scientific names: *Dendroctonus arizonicus* Hopkins
Order and Family: Coleoptera: Scolytidae
Common names: southern pine beetle; bark beetle; el gorgojo (Central America); tree killer

Dendroctonus frontalis Zimmerman, 1868 is considered to be one of the most damaging species of bark beetles in Central America and southern areas of North America. It is a major pest of pines and has a wide distribution occurring from Pennsylvania in the United States south to Mexico and Central America.

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Southern pine beetle, Dendroctonus frontalis*. On the right, an adult is compared to a grain of rice and an adult black turpentine beetle (l-r)*

DISTRIBUTION

Native: Latin America and the Caribbean: Central America (Belize, El Salvador, Guatemala, Honduras, Nicaragua), Mexico
North America: southern United States
Introduced: Europe: Ireland (intercepted only)
Near East: Israel (intercepted only)

IDENTIFICATION

Adult southern pine beetles are short-legged, stout, about 3 mm long and dark reddish brown to black in colour (Thatcher and Barry, 1982; USDA Forest Service, 1989). The front of its head is notched and the hind end of the body is rounded. Newly emerged adults are soft-bodied and amber coloured but quickly harden and darken in colour (Thatcher and Barry, 1982). Larvae are crescent-shaped, whitish with an amber head and approximately the same length as adults when fully developed (USDA Forest Service, 1989). The pupae are also the same size and white. Eggs are smooth, pearly-white and found in notches along either side of the adult egg galleries.

HOSTS

Pinus spp., primarily *P. taeda*, *P. echinata*, *P. elliottii*, *P. virginiana*, *P. rigida*, *P. palustris*, *P. serotina, P. pungens* and the introduced *P. strobes* in southeastern United States; *P. ponderosa, P. engelmannii* and *P. leiophylla* in southwestern United States; and *P. caribaea*, *P. engelmannii*, *P. leiophylla*, *P. maximinoi* and *P. oocarpa* in Central America.

BIOLOGY

Adult females lay eggs along S-shaped galleries constructed in the inner bark/sapwood interface (Billings *et al.*, 2004). Larvae feed in the inner bark and pupate in chambers near the bark surface. After completing their development, the new adults tunnel their way through the bark, creating small, round exit holes, and fly to new host trees. The beetles introduce a blue-stain fungus which penetrates into the wood interfering with the uptake of water and nutrients and quickly reducing the marketability of the trees (Billings *et al.*, 2004). All life stages of the southern pine beetle overwinter beneath or within the bark (Thatcher and Barry, 1982).

Initial attacks are generally on weakened trees; however *D. frontalis* is capable of killing otherwise healthy trees. Other characteristics that contribute to the destructive potential of this beetle include: a rapid life cycle with up to ten overlapping generations per year; the ability of females to establish multiple broods (Payne, 1980); the ability to infest and kill pines of all ages beyond five years as infestations expand, regardless of the physiological condition of the host trees (Lorio, 1980); and infestation cycles that reach peak levels every six to nine years in certain portions of its range.

Once an attack is initiated on the tree trunk, the beetles release aggregation pheromones to attract other individuals of both sexes (Billings *et al.*, 2004). Thousands of adult beetles may respond to these pheromones and resin odours, and their concentrated attack overcomes the tree's defence system of resin production. The presence of aggregation pheromones often leads to the attack of trees on the periphery of the infestation by emerging beetles, causing the infestation to rapidly expand and increase tree mortality (Payne, 1980).


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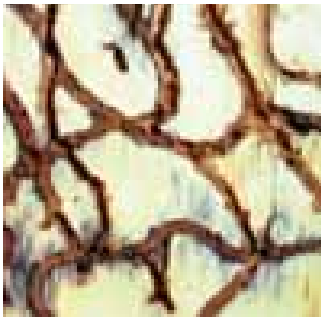
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Southern pine beetles damage host trees by creating galleries and introducing blue-stain fungi

SYMPTOMS AND DAMAGE

Discoloured tree foliage is often the first indication of beetle attack; needles become yellowish, change to red, and eventually become brown within 1 to 2 months (Thatcher and Barry, 1982). Pines are often killed in groups ranging from a few trees to those covering several hundred acres.

Another typical indication of beetle attack is the presence of pitch tubes, small yellowish-white masses of resin 6 to 13 mm in diameter, on the trunk of host trees which mark the points of beetle attack (Thatcher and Barry, 1982). However, drought-stressed trees may not produce pitch tubes in which case reddish boring dust in bark crevices or at the base of the infested tree may be the only indication of attack.

Characteristic S-shaped egg galleries that cross one another in the inner bark and on the wood surface can be observed upon removal of the bark (Thatcher and Barry, 1982). Adults or larvae may be observed in the galleries or around them if an attack is recent and with time most of the brood can be seen by chipping or shaving the bark (Thatcher and Barry, 1982).


G. ALLARD


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Pine trees damaged by the southern pine beetle

In the five years following Hurricane Mitch in 1998, over 100 000 ha of pine forest in Central America were infested mainly with *D. frontalis* in association with other species of *Dendroctonus* and *Ips* spp. The resulting extensive tree mortality severely increased the risk of wildfires and negatively affected wildlife and recreation causing widespread and significant economic impacts.

DISPERSAL AND INTRODUCTION PATHWAYS

Some bark beetles are strong fliers with the ability to migrate long distances. However, the most common pathway of introduction into new areas is through transport of untreated sawn wood and wooden packaging materials with bark on them. Dunnage is also a high risk category of material. If wood is debarked, there is no possibility of introducing bark beetles.

CONTROL MEASURES

The preferred approach for mitigating losses from southern pine beetle attacks is an integrated pest management (IPM) programme involving preventative, detection and control measures (Billings *et al.*, 2004).


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Direct control methods used against the southern pine beetle include cut-and-leave, salvage removal and application of chemical insecticides

Preventative measures include thinning to reduce stand density, removing damaged and weakened trees, and harvesting before trees become overmature. Once an outbreak begins, attention shifts to prompt detection and suppression of individual infestations which can substantially reduce resource loss (Clarke and Billings, 2003). Direct control methods include salvage removal, cut-and-leave, chemical insecticides, and burning infested trees. Cut-and-leave is a technique used solely for *D. frontalis* that consists of felling all trees with fresh attacks or bark beetle broods plus a buffer strip of adjacent uninfested trees and leaving them on site (Billings *et al*., 2004). This procedure reduces beetle survival within infested trees and prevents infestations from growing larger by disrupting pheromone production. Natural enemies, such as diseases, parasites, predators, woodpeckers and weather, may help maintain beetle populations at low levels and bring outbreaks under control.

Dendroctonus frontalis is an A1 quarantine pest for EPPO and member countries are recommended to prohibit the import of *Pinus* commodities from countries where the pest occurs, and optionally also bark of *Pinus* (EPPO/CABI, 1997). If bark is imported, then it is recommended that it be heat-treated or fermented and pine wood from such countries should be debarked, kiln-dried or treated.

Dendroctonus ponderosae

Other scientific names: *Dendroctonus monticolae* Hopkins
Order and Family: Coleoptera: Scolytidae
Common names: mountain pine beetle; bark beetle; Black Hills beetle

The mountain pine beetle, *Dendroctonus ponderosae* Hopkins, is the most destructive pest of mature pines in North America, lodgepole pine (*Pinus contorta*) in particular. Major outbreaks of this pest have been occurring in western regions of the United States and Canada causing the death of millions of trees. Local climatic changes and increased winter temperatures has exacerbated the problem.

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Adult mountain pine beetle

DISTRIBUTION

Native: North America (Canada, Mexico, United States)
Introduced: No records to date

IDENTIFICATION

Adult *D. ponderosae* are small, black, cylindrical beetles about the size of a grain of rice at 4 to 7.5 mm long. Larvae are legless, creamy-white with light brown heads and about 6 to 7 mm long when fully grown (Langor, 2003). Eggs are smooth, oval, white and translucent.

HOSTS

Primary hosts of the mountain pine beetle are *Pinus contorta* and *P. ponderosa* but *P. albicaulis*, *P. contorta* var. *latifolia*, *P. lambertiana*, *P. monticola*, *P. nigra*, and *P. sylvestris* are also attacked. This pest has also been recorded on *P. aristata*, *P. balfouriana*, *P. coulteri*, *P. edulis*, *P. flexilis*, *P. monophylla* and other pines. *Pseudotsuga menziesii*, *Libocedrus decurrens, Abies* spp., *Larix* spp. and *Picea* spp. such as *Picea engelmannii* are occasionally attacked, particularly near infested pines. These hosts are not used for reproduction, however.

BIOLOGY

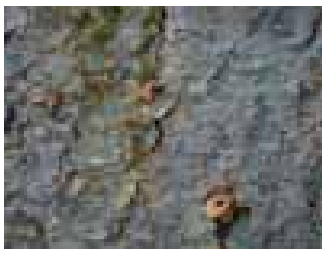
Except for a few days during the summer when adults emerge and fly to new host trees, all life stages of the mountain pine beetle are spent under the bark of infested trees. Their life cycle is generally completed in one year although warmer temperatures can result in two generations per year and beetles in high altitudes and cool temperatures may require two years to complete the life cycle (Amman, McGregor and Dolph, 1990).

Female beetles making the first attacks release aggregating pheromones which attract males and other females until a mass attack overcomes the host tree. In mid-summer, adult females attack new host trees by boring through the bark to the sapwood. They construct vertical galleries in the phloem where, after the males join them, they mate and then deposit their eggs. The eggs hatch in 10 to 14 days although it may take longer in cool weather (Amman, McGregor and Dolph, 1990). Larvae feed outwards from the egg galleries on the phloem tissue of the host tree until early fall, overwinter, and continue feeding in the spring (Langor, 2003). Pupation takes place in late spring to early summer and the new beetles feed under the bark for a few days before emerging to fly and attack new host trees in the summer following the initial attack. Adult beetles introduce a blue-stain fungus into the sapwood of the tree that prevents the tree from repelling and killing the beetles with pitch flow (Langor, 2003).

SYMPTOMS AND DAMAGE

Symptoms of attack by *Dendroctonus ponderosae* are first detectable only from the ground and require close examination of trees (Langor, 2003). Conspicuous pitch tubes, masses of red, amorphous resin mixed with bark and wood borings, are produced on the bark surface at the site of attack (Hagle, Gibson and Tunnock, 2003). Pitch tubes may be less obvious on trees suffering from severe drought stress prior to attack (Langor, 2003). Boring dust is also evident in bark crevices and around the base of infested trees.

Removal of the bark from infested trees reveals the characteristic symptoms of a vertical parent gallery with a slight J-like hook at the bottom and evenly spaced larval feeding galleries extending at right angles from the parent gallery (Unger, 1993). One or more life stages may also be present depending on the time since attack (Langor, 2003). The fungi transmitted by adult beetles produce a greyish-blue staining of the sapwood of the host tree which can be observed shortly after a successful attack (Langor, 2003). This fungi blocks the flow of water and nutrients throughout the tree which kills the host tree within a few weeks of successful attack (Langor, 2003).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Symptoms of attack by the mountain pine beetle: pitch tubes, galleries and blue-stain

During the fall and winter after attack, woodpeckers often feed on bark and wood-boring insects on infested trees. Bark stripped from the tree trunk, particulary in thin-barked hosts such as lodgepole pine, and piles of bark fragments accumulated on the ground at the base of trees are evidence of woodpecker foraging (Hagle, Gibson and Tunnock, 2003; Langor, 2003).

Foliage symptoms are generally not obvious until shortly before the mature adults fly from the tree in the summer following attack.


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Red foliage colour indicative of attack by the mountain pine beetle

The needles of infested trees first turn a faint yellow and then a bright red, which can be mapped in aerial overview surveys (Langor, 2003). Foliage fades to a dull red or reddish-brown in the second year following attack. Three or four years after the initial attack, very little foliage will remain on the host tree.

In addition to the death of trees and forests, outbreaks of *D. ponderosae* upset harvesting plans, reduce the aesthetic values in recreational areas, and increase fire hazard.

Since the first recorded infestations in 1913 in the Okanagan and Merritt areas of Canada, major infestations have occurred regularly killing over 500 million trees by the early 1990s. The current outbreak began to intensify in the northern part of British Columbia's Tweedsmuir Provincial Park in 1993 (CFS, 2007). Successive years of mild winters have allowed the beetle population to grow and spread further each year through the lodgepole pine forests making the current outbreak the largest ever recorded in North America. The large numbers of dead and dying trees have also increased the risk of wildfires. It has been predicted that if the beetle continues to spread at its current rate, as much as 80 percent of mature pine will be dead by 2013 (CFS, 2007).

DISPERSAL AND INTRODUCTION PATHWAYS

Bark beetles are strong fliers with the ability to migrate long distances. The most common pathway of introduction into new areas is through transport of untreated sawn wood and wood packaging materials with bark on them. If wood is debarked, there is no possibility of introducing bark beetles.

CONTROL MEASURES

The options available for controlling *Dendroctonus ponderosae* depend somewhat on the size of the outbreak, the age of the stand, the size of host trees, and the site conditions. Current approaches to the present outbreak include preventative management to reduce tree, stand and landscape susceptibility and direct control strategies such as logging infested and dead trees (Langor, 2003).

Silvicultural control measures, such as thinning stands, patch cutting, selective harvesting and salvage logging, are the most efficient (Amman, McGregor and Dolph, 1990; Langor, 2003). Some other direct control measures include felling and burning trees and debarking.

To provide a temporary control measure that slows infestations, insecticides are available. However if beetle outbreaks are large, chemical control is not cost effective (Amman, McGregor and Dolph, 1990; Langor, 2003). Preventive spraying can help protect individual high-value trees.

Baiting and trapping with synthetic beetle attractants can help manipulate and monitor small outbreaks by localizing infestations and preventing spread into susceptible stands (Amman, McGregor and Dolph, 1990).


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Silvicultural measures used to control the mountain pine beetle include thinning and felling of infested trees

Natural enemies of this pest species include woodpeckers, nematodes, predaceous insects, such as *Enoclerus sphegeus*, *Laphria gilva*, *Lonchaea* sp., *Medetera aldrichii*, *Temnochila chlorodia*, *Thanasimus undatulus* and *Xylophagus* sp., and parasitic insects, such as *Coeloides dendroctoni*, *Dinotiscus burkei* and *Roptrocerus eccoptogastri* (Bellows, Meisenbacher and Reardon, 1998). These natural enemies are likely most important in limiting or controlling the pest at low populations; during outbreaks, they appear less able to exert sufficient limits on the population.

Dendroctonus ponderosae is an A1 quarantine pest for EPPO and member countries are recommended to prohibit the import of *Pinus* commodities from countries where the pest occurs, and optionally also bark of pines (EPPO/CABI, 1997). If bark is imported, then it is recommended that it be heat-treated or fermented and pine wood from such countries should be debarked, kiln-dried or treated.

Dendroctonus valens

Other scientific names: *Dendroctonus rhizophagus*
Order and Family: Coleoptera: Scolytidae
Common names: red turpentine beetle; bark beetle

The red turpentine beetle, *Dendroctonus valens* LeConte, is a common pest of forest, shade and park trees of pole size or larger. It is native to North America and was accidentally introduced into China in the 1980s presumably on unprocessed logs imported from the western United States. Red turpentine beetles can be distinguished from engraver beetles by their larger size, reddish-brown colour and the presence of large, pinkish brown to white pitch tubes, a mixture of pine sap and beetle boring dust, on the lower trunk of infected hosts.

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Adult red turpentine beetle, Dendroctonus valens

DISTRIBUTION

Native: Latin America and the Caribbean: portions of Central America, Mexico (Wood, 1982)
North America (Wood, 1982)
Introduced: Asia and the Pacific: China (mid 1980s)

IDENTIFICATION

Eggs are shiny, opaque white, ovoid cylindrical, and a little over 1 mm in length (Smith, 1971). Larvae are grublike, legless and white with a brown head capsule and a small brown area at the hind end (Smith, 1971). A row of small, pale-brown tubercles develop along each side of the body. Full grown larvae are approximately 10 to 12 mm long. Pupae are white and slightly shorter than the larvae.

Adult beetles are typically long and stout, about 6 to 10 mm long and dark brown to black in colour with reddish-brown wing covers (Smith, 1971; Hagle, Gibson and Tunnock, 2003).

HOSTS

In its native range, hosts include: *Pinus* spp., including *P. resinosa*, *P. contorta*, *P. banksiana*, *P. strobes*, *P. rigida*, *P. echinata*, *P. radiata*, and *P. ponderosa*; *Picea* spp.; *Larix* spp.; *Abies* spp.; and *Pseudotsuga menziesii.* In its introduced range in China, hosts are primarily *Pinus tabulaeformis* and *P. armandii* and occasionally *Picea* and *Abies* species.

BIOLOGY

Peak flight and activity usually occur in the spring when adult beetles emerge from recently cut stumps and dying trees to attack trees, exposed roots, or freshly cut stumps (Smith, 1971). The female beetle bores through the bark to the surface of the wood where she is soon joined by a male. Typically one pair of beetles is found in an individual gallery but occasionally there may be one, three, or four beetles present. Resin mixed with boring particles and frass is pushed to the outer bark surface forming a pitch tube or dropping in pellets to the base of the tree (Smith, 1971).

Eggs are deposited on alternate sides of the gallery (Hagle, Gibson and Tunnock, 2003). The egg mass can extend from one to several inches along the gallery and the number of eggs it contains varies from a few to more than a hundred (Smith, 1971). The adult beetles continue to feed in the gallery for several weeks and then they either bore out through the bark and make additional attacks or die within the gallery. The eggs hatch in 1 to 3 weeks during the summer months.

Larvae feed gregariously in the phloem often forming fan-shaped galleries. Larvae are present for two summers after which they pupate and then overwinter the second year as adults beneath the bark (Hagle, Gibson and Tunnock, 2003). In standing trees, adults briefly emerge in their second fall and re-enter the tree to overwinter beneath the bark at the root collar where they are protected from the elements.

The rate of development and the number of generations per year are largely dependent on temperature (Smith, 1971). In warmer regions there is at least one generation per year while in northern areas at high elevations two years may be required for a single generation. In southern areas at low elevations, there may be as many as three generations per year.

SYMPTOMS AND DAMAGE

The red turpentine beetle usually attacks trees of reduced vigour or those infested with other bark beetles, but it can attack healthy trees. It is often found in association with other bark and wood-boring beetles such as *Ips* spp. and other *Dendroctonus* spp.

Attacks on standing trees are concentrated on the lower trunk and exposed roots. Large reddish-white pitch tubes on the bark or pellets on the ground around the base of host trees from mid-May to July are usually the first sign of infestation (Hagle, Gibson and Tunnock, 2003). Feeding by larvae and adults in galleries can completely girdle the trees resulting in death although this is not always the case. Host trees are inoculated with blue-stain fungi. Freshly cut logs with thick bark may be attacked and while they will not produce large numbers of beetles, they can multiply and threaten nearby trees (Smith, 1971). Attacks, especially on healthy trees, may last for two years or more. Severe attacks can kill trees.

Despite the abundance and wide distribution of *D. valens*, outbreaks have not been extensive or severe in the United States (Smith, 1971). The beetle has been found most frequently in individual trees or in groups of trees in localized areas. In China, however, it is considered an aggressive and very destructive pest of *Pinus tabuliformis*, China's most widely planted pine species. It was first detected in Shanxi Province in 1998 and widespread tree mortality was reported in 1999; this outbreak continues and has spread to three adjacent provinces causing unprecedented tree mortality (Yan *et al*., 2005).

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Pitch tubes evident on a host tree infested with Dendroctonus valens

DISPERSAL AND INTRODUCTION PATHWAYS

The beetles are strong fliers capable of flying more than 10 miles (Smith, 1971). This species can also be introduced into new areas on forest products and wood packaging materials as evidenced by its arrival in China in the 1980s.

CONTROL MEASURES

Once attacked a tree typically cannot be saved therefore preventive measures such as maintaining the health and vigour of forest stands by thinning or removal of overmature trees are the best tactics to reduce the impacts of this pest. Chemicals have been used in some areas and have been shown to help prevent attacks and kill beetles already beneath the bark.

In China, a variety of methods from informal surveys to the use of baited traps are used to detect and monitor *Dendroctonus valens* populations. In addition, investigations are underway on the use of the predator *Rhizophagus grandis* for biological control.

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Damage caused by Dendroctonus valens *in the United States (left) and Shanxi Province, China (right)*

Dendrolimus sibiricus

Other scientific names: *Dendrolimus laricus* Tschetverikov; *Dendrolimus superans sibiricus* Tschetverikov
Order and Family: Lepidoptera: Lasiocampidae
Common names: Siberian caterpillar; Siberian silk moth; Siberian moth; Siberian conifer silk moth; Siberian coniferous silk moth; Siberian lasiocampid; larch caterpillar

Widespread on the Asian continent, *Dendrolimus sibiricus* Tschetverikov is a destructive pest of conifers causing significant defoliation of trees in both naturally regenerated and planted forests. It is able to attack and kill healthy trees and it has been known to kill forests across very wide areas.


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Dendrolimus sibiricus *life cycle stages: eggs, larva, pupae, adult*

DISTRIBUTION

Native: Asia and the Pacific: Democratic People's Republic of Korea, Kazakhstan, Mongolia, People's Republic of China, Republic of Korea,
Europe: Russian Federation
This pest is believed to have originated in Siberia.
Introduced: No record to date but this pest poses a real threat

IDENTIFICATION

Adult Siberian moths are yellowish-brown or light grey to dark brown or almost black. The forewings are marked by two characteristic dark stripes and a white spot in the centre. Hind wings are the same colour as the forewings but lack markings. Females are approximately 40 mm long with a wing span of 60 to 80 mm while males are approximately 30 mm long with a 40 to 60 mm wing span (Kimoto and Duthie-Holt, 2006; EPPO, 2005).

Larvae are mainly black or dark brown with numerous spots and long hairs. They are 55 to 70 mm long and the second and third segments are marked with blue-black stripes (Kimoto and Duthie-Holt, 2006). Reddish setae are found on the sides of larvae, usually as red jagged bands or spots.

Eggs are oval, 2.2 mm long and 1.9 mm wide. Initially light-green in colour, they turn creamy-white and darken and become spotted over time (Kimoto and Duthie-Holt, 2006; EPPO, 2005).

HOSTS

Larix spp., including *L. gmelinii* and *L. sibirica*; *Pinus* spp., including *P. sibirica* and *P. koraiensis*; *Abies* spp., including *A. sibirica* and *A. nephrolepis*; *Picea* spp., including *P. ajanensis* and *P. obovata*; and *Tsuga* spp.

BIOLOGY

Spring flight usually occurs in mid-July. Immediately after mating, females lay eggs on the needles primarily in the lower part of the crown although during outbreak years, eggs are laid throughout the tree and on the surrounding ground. One egg mass may contain 1 to 200 eggs (Kimoto and Duthie-Holt, 2006; EPPO, 2005). Each female lays an average of 200 to 300 eggs, with a maximum of 800 (EPPO, 2005). Egg development typically takes 13 to 15 days with an occasional maximum of 20 to 22 days (EPPO, 2005).

There are 6 to 8 larval instars. First instar larvae eat the edges of needles and moult in 9 to 12 days while second instar larvae cause further damage to the needles and develop for 3 to 4 weeks before moulting (EPPO, 2005). The third instar larvae descend to the soil in September and overwinter in the top layers of soil. In the spring of the following year, the larvae return to the crowns to feed, eating complete needles and sometimes the bark of young shoots and cones. They moult after one month and again at the end of July or in August. In autumn, the larvae return to the soil and overwinter for a second time.

In the following spring, when the temperature of the forest floor rises to 3.5 to 5.0 °C, the larvae break diapause and ascend to the tree crowns to resume feeding. During this period, they eat about 95 percent of the food they need for development and it is then that the major damage occurs (Orlinski, 2000). Larvae finish maturation feeding by late June or early July and pupate in the crowns of trees where they form silken cocoons intertwined with foliage and branches. The pupal stage last from 18 to 22 days after which the adults emerge and the cycle begins again.

The full life cycle usually takes two years. However in southern parts of its native range one generation can develop in a single year while in northern regions it may take up to three years (Orlinski, 2000). Drought, increasing population density and other factors cause some larvae to have a shorter, two calendar-year life cycle. As a result, the adults of two generations emerge simultaneously and the population increases sharply. Competition for food may extend larval development and increase the number of instars.

Outbreaks of this moth are cyclic, occurring every 8 to 11 years following a few years of water shortage and last for 2 to 3 years. The period between outbreaks is becoming shorter partly due to changing climate.

SYMPTOMS AND DAMAGE

The Siberian caterpillar causes significant defoliation of both naturally regenerated and planted forests. It is able to attack and kill healthy plants and it has been known to kill trees and forests across very wide areas. Death of forests can be caused directly by defoliation or indirectly by increasing the susceptibility of the forest to subsequent attack by other forest pests such as bark beetles or forest fires (Orlinski, 2000). Other effects of *D. sibiricus* attack include the loss of vigour, reduction in growth, and reduced seed crops.

The duration and effect of outbreaks depends on the forest type (Ghent and Onken, 2004). Outbreaks in fir and five-needled pines result in defined focal areas with very

high densities of larvae that defoliate trees for two or three successive years before the outbreak collapses. Tree mortality is virtually 100 percent in many stands. Outbreaks in larch forests are more prolonged but cause less tree mortality. Moths migrate from defoliated larch hosts to new areas to lay eggs. As a result, successive years of severe defoliation rarely occur and the outbreak population becomes dispersed.

As well as the impact on trees and forests, Siberian caterpillars have stinging hairs that can cause significant allergic reactions in people living near and visiting forests as well as forest workers. Exposure to the larval hairs or secretions of the Siberian caterpillar produces severe dermatitis as well as systemic reactions affecting the joints and other parts of the body.

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*Siberian larch (*Larix sibirica*) defoliated by the Siberian caterpillar, Mongolia*

DISPERSAL AND INTRODUCTION PATHWAYS

Adults are strong fliers and can spread fairly rapidly. Pathways of introduction include natural movement of adults and the movement of eggs on nursery stock or forest products.

CONTROL MEASURES

Ground and aerial application of chemical and bacterial insecticides, such as *Bacillus thuringiensis* var *kurstaki* (Btk), has been used to control *Dendrolimus sibiricus* in countries within the native range of the pest.

Natural enemies of the Siberian caterpillar, including several parasitoids and pathogens, play an important role in the regulation of population density. Examples include the egg parasitoids *Telenomus gracilis*, *T. tetratomus*, and *Trichogramma dendrolimi*; the larval and pupal parasitoids *Ooencyrtus pinicolus* and *Rhogas dendrolimi*; the bacteria *Bacillus dendrolimus* and *B. thuringiensis*; the fungus *Beauveria bassiana*; and some viruses (Orlinski, 2000; EPPO, 2005).

In 2002, *D. sibiricus* was added to the EPPO A2 action list and it has been recommended that EPPO member countries regulate it as a quarantine pest. Since *D. sibiricus* is apparently slowly spreading westwards through Europe, carrying out surveys using pheromone traps and applying appropriate control measures in areas at the border of the pest's present range would help avoid the possible introduction of this pest into new areas (EPPO, 2005).

To prevent the introduction of *D. sibiricus*, it is recommended that: commodities, plants for planting and cut branches of host plants from infested areas should be free of soil; commodities should originate in a pest-free area, be produced in protected houses, fumigated, or be imported during winter; and wood should be debarked, heat-treated, originate in a pest-free area, or be imported during winter, and isolated bark should be treated to destroy any insects (EPPO, 2005).

Gonipterus scutellatus

Order and Family: Coleoptera: Curculionidae
Common names: eucalyptus weevil; eucalyptus snout beetle

Gonipterus scutellatus Gyllenhal, 1833 is a leaf-feeding beetle that is a major defoliator of eucalypts. It is indigenous to Australia but occurs in many countries throughout the world where eucalypts are grown. Infestations of this beetle are known to cause serious damage. This pest is a major threat worldwide as it continues to spread, both within continents where it currently occurs and to previously uninfested continents.

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Adult Gonipterus scutellatus

DISTRIBUTION

Native: Asia and the Pacific: Australia
Introduced: Africa: Kenya, Lesotho, Madagascar, Malawi, Mauritius (1940), Mozambique, South Africa (1916), St. Helena, Swaziland, Uganda, Zimbabwe
Asia and the Pacific: New Zealand, People's Republic of China
Europe: France (1977), Italy (1975), Portugal (1990s), Spain (1991)
Latin America and the Caribbean: Argentina, Brazil, Chile, Uruguay
North America: United States (1990s)

IDENTIFICATION

Approximately 12 to 14 mm in length, adult eucalypt weevils vary in colour from grey to reddish-brown with a light, transverse band on the back and are covered by small pale brown hairs (Phillips, 1992). It is very similar to the Australian gum tree weevil, *Gonipterus gibberus*.

Larvae are approximately 10 to 14 mm long, yellowish-green in colour with black spots and a black stripe running along each side of the body (Phillips, 1992; EPPO, 2005). They often have a characteristic long thread of faecal material coiled up behind them.

Eggs are laid in greyish or blackish-brown coloured capsules on both surfaces of the leaves (Phillips, 1992). These capsules are approximately 3 mm in length, 2 mm high and 1.5 mm in width and contain 3 to 16 pale yellow eggs arranged in vertical layers.

HOSTS

Eucalyptus spp., including *E. camaldulensis*, *E. cornuta*, *E. globulus* ssp. *globulus*, *E. grandis*, *E. kirtoniana*, *E. longifolia*, *E. maidenii* ssp. *globulus*, *E. obliqua*, *E. propinqua*, *E. punctata*, *E. robusta*, *E. smithii*, *E. tereticornis*, *E. urnigera* and *E. viminalis.*

Differences in susceptibility exist among eucalypt species (Rivera and Carbone, 2000). In Mauritius, *E. robusta*, *E. tereticornis* and *E. kirtoniana* are the most susceptible eucalypt species while in Kenya, *E. globulus* ssp. *globulus*, *E. maidenii* ssp. *globulus*, *E. robusta* and *E. smithii* are the most commonly attacked and *E. saligna* and *E. citriodora* are known to be practically immune. In Madagascar, the most susceptible species were *E. cornuta*, *E. viminalis*, *E. punctata*, *E. globulus* ssp. *globulus*, *E. urnigera* and *E. camaldulensis*; in Spain, *E. globulus* ssp. *globulus* and *E. obliqua* were most commonly attacked; and in Italy, *G. scutellatus* showed a clear preference for the leaves of *E. globulus ssp. globulus* and did not attack *E. cinerea*, *E. gunnii*, *E. polyanthemos*, *E. stuartiana* and *E. rostrata*. Another report from Spain reported that *G. scutellatus* exhibited a clear preference for *E. globulus ssp. globulus*, *E. longifolia*, *E. grandis* and *E. propinqua* and completely avoided other species although they noted that less palatable species might be used by the insect if preferred species were absent (Rivera and Carbone, 2000).

BIOLOGY

Females mate several times and lay their eggs in batches covered by a capsule on both surfaces of new leaves.

They continue to lay eggs, up to 21 to 33 capsules, throughout a lifetime of about 91 days (EPPO, 2005). Eggs hatch in 3 to 4 weeks and the larvae feed on leaves and twigs and then pupate in the soil. Adults also feed on leaves and growing shoots.

There is usually more than one generation per year, with females living for about three months and larval development taking between 30 and 80 days. In some places there are continuous generations.

SYMPTOMS AND DAMAGE

Adults and larvae feed on the leaves of host trees but it is the larval stage that does the most damage. They cause damage by eating only one surface of the leaves, leaving characteristic tracks while adults chew the edges of the leaves giving them a ragged, scalloped appearance (Phillips, 1992). Both adults and larvae prefer the newly expanded adult leaves and shoots. Such feeding can result in dieback of shoot tips and development of tufts of epicormic shoots (EPPO, 2005).

Severe infestations and successive defoliations by this beetle can cause tree mortality, reduction in growth, coppicing and stunting of trees, although some *Eucalyptus* spp. are more susceptible to damage than others. Young trees are the most susceptible but seedlings may also be attacked.

DISPERSAL AND INTRODUCTION PATHWAYS

Dispersal is by adult flight, adults hitch-hiking on non-plant material, and movement of infested plant material or soil.

CONTROL MEASURES

Biological control of this species by means of the importation of *Anaphes nitens* (Hymenoptera: Mymaridae), an egg parasitoid, has been highly successful in many areas. Where the biological control of *G. scutellatus* is unsuccessful, the alternative is to use tolerant host plant species (Rivera and Carbone, 2000). Chemical treatment is not recommended because of the potential danger to beneficial honey bees attracted to the flowers of eucalypt species (EPPO, 2005).

Gonipterus scutellatus is an A2 quarantine pest for EPPO and is also of phytosanitary significance for COSAVE. It is regulated by most EPPO countries, in particular by the EU, and recommended measures require that *Eucalyptus* plants for planting (except seeds) and cut branches should come from a pest-free area or plants should be free from soil and treated against *G. scutellatus* (EPPO, 2005).

Heteropsylla cubana

Other scientific names: *Heteropsylla incisa* Sulc.
Order and Family: Hemiptera: Psyllidae
Common names: leucaena psyllid

Heteropsylla cubana Crawford, 1914 is a significant pest of *Leucaena leucocephala*, a tree grown extensively in community forestry and agroforestry ecosystems for fodder and fuelwood throughout the tropics, causing defoliation, wilting, dieback, and in some cases, tree death. It is native to Central and South America but has dramatically spread from its native range, across the Pacific Ocean to Asia and the Pacific and Africa in less than 10 years. In many countries where leucaena has been introduced it is now considered a highly invasive tree. As a result, *H. cubana* may be considered more of a biological control agent than a forest pest.

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Infestation of the leucaena psyllid, Heteropsylla cubana*, near Mombasa, Kenya*

DISTRIBUTION

Native: Latin America and the Caribbean
Introduced: Africa: Burundi (1992), Ethiopia (1993), Kenya (1992), Malawi (1994), Mauritius (1991), Mozambique (1993), Réunion (1991), Sudan (1994), the United Republic of Tanzania (1992), Uganda (1992), Zambia (1994)
Asia and the Pacific: Australia (1986), Bangladesh (1987), Cambodia (1986), China (1986), Cook Islands (1985), Fiji (1985), Guam (1985), India (1988), Indonesia (1986), Malaysia (1986), Myanmar (1986), Nepal (1987), New Caledonia (1985), Papua New Guinea (1985), the Lao People's Democratic Republic (1986), Philippines (1985), Singapore (1986), Solomon Islands (1985), Sri Lanka (1987), Tahiti (1985), Thailand (1986), Tonga (1985), Viet Nam (1986)
North America: United States (1993)

IDENTIFICATION

Adult psyllids are aphid-like, approximately 2 mm in length, winged and light green to yellow in colour. If disturbed, they use stout legs to jump before taking flight. Nymphs are similar to adults in appearance except they are smaller, wingless and remain on the plant if disturbed. They undergo five instars over 8 to 9 days (Moog, 1992). Eggs can be barely seen with the naked eye primarily on young terminal leaves; in large numbers they appear as orange-yellow masses.

HOSTS

Leucaena spp. in particular *Leucaena leucocephala*, but also *L. trichodes*, *L. pulverulenta*, *L. diversifolia*, *L. salvadorensis* (Nair, 2001); *Albizia* spp.; *Mimosa* spp.; *Samanea saman*

BIOLOGY

Females begin laying eggs 1 to 3 days after becoming adults (Moog, 1992). Eggs are laid on and between new leaves on young shoot tips and hatch in 2 to 3 days. The insect is most common on young growth where eggs, nymphs and adults often occur together (Hertel, 1998). The cycle from egg to adult takes 10 to 20 days. Psyllids prefer high relative humidity and temperatures in the 20s (°C). Adults feed on young growth and occasionally older growth and flowers.

SYMPTOMS AND DAMAGE

Adults and nymphs suck the sap of the terminal leaves, buds and flowers of host plants which reduces flower and seed production and causes new shoots and foliage to become stunted and deformed rendering the foliage useless for fodder or human consumption. In addition, honeydew produced by the psyllids permits the growth of sooty moulds which prevents light from reaching the leaf surfaces thereby reducing photosynthesis and plant production. Repeated attacks cause wilting, defoliation, branch dieback or death of host trees (Hertel, 1998).

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Leucaena psyllid damage, Kenya

DISPERSAL AND INTRODUCTION PATHWAYS

The quick and impressive spread of leucaena psyllid, over large areas and regions has led to speculation that wind dispersal plays a major role as opposed to human-assisted dispersal (Ciesla, 1998).

CONTROL MEASURES

Measures aimed at controlling the leucaena psyllid have primarily concentrated on the development of resistant leucaena varieties and the use of biological control agents. Biological control agents for the leucaena psyllid include the predators, *Curinus coeruleus* and *Olla v-nigrum* (Coleoptera: Coccinellidae), and the parasitoids, *Psyllaephagus yaseeni* (Hymenoptera: Encyrtidae) and *Tamarixia leucaenae* (Hymenoptera: Eupelmidae) (FAO, 1998).

Hypsipyla grandella and *Hypsipyla robusta*

***Hypsipyla grandella* Zeller, 1848**
Order and Family: Lepidoptera: Pyralidae
Common names: mahogany shoot borer

***Hypsipyla robusta* Moore, 1886**
Other scientific names: *Epicrocis terebrans* Oliff, 1890; *Magiria robusta* Moore, 1886; *Hypsipyla scabrusculella* Ragonot, 1893; *Hypsipyla pagodella* Ragonot, 1888
Order and Family: Lepidoptera: Pyralidae
Common names: mahogany shoot borer; cedar tip moth; toon shoot fruit borer

Hypsipyla shoot borers are a significant threat to many high value timber species belonging to the Meliaceae and Verbenaceae, including species of *Swietenia*, *Khaya*, *Toona, Tectona* and *Cedrela*. The two most important *Hypsipyla* species are *H. grandella* in the Americas, and *H. robusta* in areas of Africa and Asia and the Pacific.

DISTRIBUTION

Hypsipyla grandella

Native: Latin America and the Caribbean: Central America, the Caribbean, Mexico, South America (except Chile)
North America: United States (southern Florida)
Introduced: The introduced range is not verified, but it is known from Mauritius (Africa).

Hypsipyla robusta

Native: Africa (West and East); Asia and the Pacific
Introduced: The introduced range is not verified.

IDENTIFICATION

Adults are brown to greyish-brown in colour with a wingspan of approximately 23 to 45 mm (Howard and Merida, 2005). The forewings are grey to brown with shades of rusty red on the lower portion and whitish scales with black dots toward the wing tips (Howard and Merida, 2005). Wing veins are distinctively overlaid with black. Hind wings are white to translucent with dark-coloured margins.

Larvae are tan to white in colour, turning bluish in later instars, with a brown head capsule (Howard and Merida, 2005). Mature larvae are approximately 25 mm long.

Pupae are brownish-black and enclosed in a silken cocoon (Howard and Merida, 2005).

Eggs are oval, dorsoventrally flattened, and measure 0.5 to 1.0 mm by 0.5 to 0.98 mm (Griffiths, 2001; Howard and Merida, 2005). When first laid they are white in colour and if fertilized, they develop distinct red and white banding within 24 hours.

HOSTS

Hypsipyla grandella

Meliaceae and Verbenaceae: *Swietenia* spp. (*S. macrophylla*, *S. mahagoni*); *Cedrela* spp.; *Tectona* spp.; *Toona* spp. (*T. australis*, *T. ciliata*); *Chukrasia tabularis*

Hypsipyla robusta

Meliaceae and Verbenaceae: *Swietenia* spp. (*S. macrophylla*, *S. mahagoni*); *Cedrella* spp. (*C. toona*); *Tectona* spp. (*T. grandis*); *Toona* spp. (*T. australis*, *T. ciliata*); *Chukrasia tabularis*; *Khaya* spp.; *Carapa procera*; *Entandrophragma* spp.; *Lovoa trichiliodes*

BIOLOGY

Females mate only once and lay 200 to 450 eggs over a period of five to eight days. On young trees, eggs are deposited singly or occasionally in clusters of 3 to 4 on the shoots, stems and leaves, particularly the upper leaf surface. Concentrated around the growing shoots, eggs may occur at all heights on the host tree and are often placed in concealed locations such as leaf axils, leaf scars, veins, lenticels and fissures in the bark (Griffiths, 2001). Eggs laid on fruit are initially deposited singly on the fruit surface but are later laid in clumps of up to 12 among the frass and webbing associated with existing damage to the fruit (Griffiths, 2001).

After three to five days, the eggs hatch and the larvae tunnel in the developing shoots of young trees and sometimes also feed upon the flowers, fruit and bark of host trees (Griffiths, 2001). They pupate either in the twigs, shoots or the soil.

A generation usually takes 1 to 2 months but may extend to five months if larvae enter diapause, which has been reported from areas of low temperature or rainfall, and occurs immediately after fruit-feeding despite apparently suitable climatic conditions (Griffiths, 2001). Adults are typically nocturnal and mate within six days of emergence.

SYMPTOMS AND DAMAGE

Hypsipyla caterpillars attack seed and fruit capsules and bore into the tips, shoots and twigs of several high quality timber species killing the first few centimeters. The caterpillars destroy the terminal shoot causing the tree to form many side branches and frequently a deformed trunk thereby significantly reducing the economic value of the timber (Griffiths, 2001). Growth rate is reduced and heavy and repeated attacks can result in tree death.

This species mainly attacks trees in areas with high light, hence the biggest effects are observed in young planted forests, particularly those planted with a single species (Nair, 2001). Young understorey trees in naturally regenerated forests suffer far less damage. The borer is a problem to both nursery and planted stock; trees from three months to fourteen years in age and between 50 cm and 15 m in height have shown symptoms of *Hypsipyla* attacks (Griffiths, 2001). It has been one of the main factors preventing the ready establishment of mahogany plantations in many areas.

DISPERSAL AND INTRODUCTION PATHWAYS

Adults are strong fliers and can travel considerable distances to locate suitable host material.

CONTROL MEASURES

Hypsipyla grandella and *H. robusta* have proven difficult to control. While some methods can significantly reduce populations, this pest can cause significant damage even at low population levels and it is therefore considered a major destructive forest pest. Three main control methods are considered to control *Hypsipyla* species: silvicultural, chemical and biological.

Silvicultural techniques applied to control *Hypsipyla* species include mixed or enrichment plantings, varying tree density, provision of shade, promoting vigourous tree growth in nurseries and plantations, and the selection of resistant or tolerant host trees.

In a review of research on the chemical control of *Hypsipyla* spp., Wylie (2001) noted that there is no single reliable, cost-effective, and environmentally sound chemical pesticide available to control these insects and suggested that chemical control of these pests might be most applicable in nursery situations or as part of an integrated pest management programme by temporarily reducing populations in limited areas.

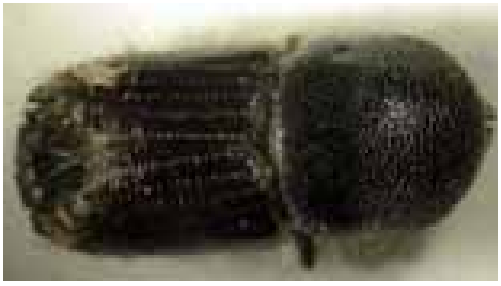
Though *H. robusta* and *H. grandella* are attacked by a range of natural enemies, they have not been shown to reduce the larval abundance and subsequent damage to acceptable levels (Sands and Murphy, 2001). Previous attempts at biological control of *Hypsipyla* species have not been successful although research into possible agents continues.

The most promising strategies for management of *Hypsipyla* species are integrated pest management programmes involving a combination of these techniques such as the use of pest tolerant host trees, planting of mixed stands and providing shade.

Ips sexdentatus

Other scientific names: *Dermestes sexdentatus* Börner; *Bostrichus pinastri* Bechstein; *Tomicus stenographus* Duftschmidt; *Ips typographus* De Geer
Order and Family: Coleoptera: Scolytidae
Common names: six-spined engraver beetle; six-toothed bark beetle; twelve-spined ips; pine stenographer beetle

Ips sexdentatus Börner, 1767 is a pest of conifer tree species in its native range of Asia and Europe. While it typically attacks stressed or weakened trees it has been known to attack and cause the death of healthy trees of commercial importance.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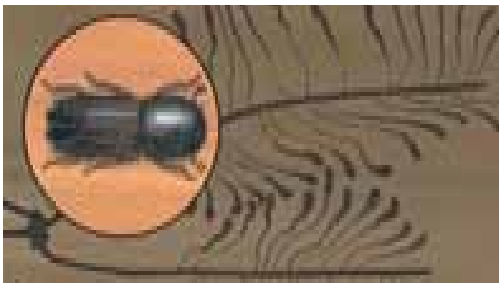
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Ips sexdentatus *adults and galleries*

DISTRIBUTION

Native: Asia and the Pacific (mainland); Europe
Introduced: No records to date

IDENTIFICATION

At approximately 5.5 to 8.2 mm in length, *Ips sexdentatus* is the largest species of its genus (Cavey, Passoa and Kucera, 1994; Kimoto and Duthie-Holt, 2006). They are cylindrical, robust, shiny, brown or brownish-black beetles with erect yellow hairs protruding from the body. The head is covered by a thoracic shield and is not visible when viewed dorsally (Kimoto and Duthie-Holt, 2006). This beetle is named for the six spines or teeth found on each side of the posterior portion of the forewings (Cavey, Passoa and Kucera, 1994).

HOSTS

Pinus spp., including *P. brutia*, *P. heldrichii*, *P. nigra*, *P. pinaster* and *P. sylvestris*; *Abies* spp., including *A. alba* and *A. normanndiana*; *Larix* spp., including *L. decidua* and *L. sibirica*; *Picea* spp., including *P. abies* and *P. orientalis*; *Pseudotsuga menzeisii*

BIOLOGY

Attacks are initiated by the males, who construct nuptial chambers under the bark, emit aggregation pheromones and are subsequently joined by 2 to 5 females (Kimoto and Duthie-Holt, 2006). After mating, each female constructs a longitudinal egg gallery, typically 15 to 35 cm long and 4 to 5 mm wide, and deposits eggs in individual niches along each side of the gallery.

Young larvae feed in galleries perpendicular to the egg galleries which are usually found in the inner bark of the lower stem. Larval galleries increase in size as the larvae grow. Pupation takes place in round chambers constructed at the ends of the larval galleries. Adults require maturation feeding before reaching sexual maturity. Round exit holes measuring approximately 4 mm in diameter are apparent on the tree trunk after adults emerge (Kimoto and Duthie-Holt, 2006).

The number of generations per year and the timing of the life cycle depend on climate. This insect typically has two generations per year, one generation north of the Arctic Circle, with adult flight periods from April to May and July to August. In the Mediterranean region and other areas with a long, warm summer season, *I. sexdentatus* can undergo four to five generations (EPPO/CABI, 1997).

SYMPTOMS AND DAMAGE

Ips sexdentatus is considered a secondary pest, often found in association with other forest pests such as *I. acuminatus* and *Tomicus piniperda*, that usually attacks trees that have been otherwise stressed or weakened and occasionally attacks freshly felled trees or windthrown trees (EPPO/CABI, 1997). It prefers to attack large trees with thick bark. It rarely attacks healthy, vigorously growing trees though it is capable of killing trees of commercial importance.

Breeding attacks by *Ips sexdentatus* are characterized by the presence of reddish-brown frass on the bark surface of host trees, freshly cut logs or windthrow (Kimoto and Duthie-Holt, 2006). If healthy, vigourous trees are attacked, pitch tubes can be found on the main stem (Kimoto and Duthie-Holt, 2006). The needles of attacked trees turn from green to yellow and then reddish-brown. As with other conifer bark beetle species, *Ips sexdentatus* is a vector for blue-stain fungi (*Ophiostoma* spp.) which hastens the death of trees, discolours the wood and can result in loss of lumber grade and value.


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Damage caused by Ips sexdentatus*: L, pitch tubes; R, discoloured needles of Austrian pine (*Pinus nigra*), France*

DISPERSAL AND INTRODUCTION PATHWAYS

Adult *Ips* beetles are capable of flying up to 4 km in search of suitable host material and they are also subject to wind dispersal. Transport of unprocessed logs, wood products, wooden packing materials, dunnage or pallets containing bark strips can provide a means of introduction of immature stages and adults.

CONTROL MEASURES

The most effective control measure against damage by *Ips sexdentatus* is to remove infested trees before the new generation of adult beetles emerges (EPPO/CABI, 1997). Debarking infested trees may also help to prevent further infestations. The use of trap trees may be helpful in controlling high density populations.

Ips subelongatus

Other scientific names: *Ips fallax* Eggers
Order and Family: Coleoptera: Scolytidae
Common names: larch bark beetle; larch engraver beetle; oblong bark beetle

Ips subelongatus Motschulsky, 1860 is considered to be the most destructive bark beetle pest of larch within its natural range. It is considered by many to be of equal importance to the European spruce bark beetle, *Ips typographus*, which is generally regarded as Europe's most damaging bark beetle.

DISTRIBUTION

Native: Asia and the Pacific (mainland)
Europe: Russian Federation
Introduced: No reports to date

IDENTIFICATION

Adult beetles are completely brown in colour and have an elongated body approximately 4.5 to 6.0 mm long (Kimoto and Duthie-Holt, 2006). The posterior end of the forewings is completely covered with long hairs and also has four spines on each side, the third of which has a characteristic bulge at the top (Kimoto and Duthie-Holt, 2006).

Eggs are round and pearly white in colour. The larvae are white grubs with amber coloured head capsules that are typically 4 to 5 mm long when mature (Orlinski, 2004).

HOSTS

Larix spp., including *L. sibirica*, *L. gmelinii*, *L. leptolepis* and *L. olgensis*; *Abies* spp.; *Picea* spp.; *Pinus* spp., including *P. sylvestris*, *P. sibirica* and *P. koraiensis*

BIOLOGY

In the southern part of its distribution, the first spring mass flight usually occurs from mid-May to the end of June, when midday temperature reaches 16 to 20 °C, and lasts for 15 to 17 days (EPPO, 2005). Attacks are initiated by the males, who construct nuptial chambers under the bark, emit aggregation pheromones and are subsequently joined by 2 to 5 females (Kimoto and Duthie-Holt, 2006). After mating, each female constructs an egg gallery, typically 16 to 18 cm long and 3 to 3.5 mm wide, and deposits her eggs. The shape and depth of egg galleries varies depending on the health of the host tree; in healthy trees, they radiate downwards and upwards from the nuptial chamber but in stressed trees they radiate vertically and horizontally (Kimoto and Duthie-Holt, 2006). Larval galleries are typically perpendicular to the egg galleries.

Adults must feed in order to achieve sexual maturity. Maturation feeding usually occurs along the trunk but may also occur on the root collar or on branches (Kimoto and Duthie-Holt, 2006). These galleries are characterized by large quantities of frass. Mature beetles overwinter in forest litter whereas pupae, larvae and some adults overwinter under the bark of larch host trees (EPPO, 2005).

SYMPTOMS AND DAMAGE

Ips subelongatus is capable of attacking both apparently healthy trees and stressed trees but they most frequently occur on trees that have been stressed by other factors such as wildfire or other pests. Mature trees are preferred. It is often found in association with infestations of other bark beetles and wood-borers such as *Scolytus morawitzi*, *Xylotrechus altaicus, Monochamus galloprovincialis* and *Melanophila guttulata* (Orlinski, 2004).

Repeated attacks by this species can affect the growth and rate of timber production, occasionally leading to dieback or death of a host tree. Characteristic symptoms of attack by *I. subelongatus* include: sparse crowns of larch trees with partly dead tops and branches; wilting of needles; fading of foliage from green to yellow and finally to red; resin flow from entrance holes; the presence of small round exit holes, pitch tubes, reddish frass on the bark surface and a gallery system with central chamber and radial larval galleries under the bark (EPPO, 2005). As with other conifer bark beetle species, *Ips subelongatus* is a vector for blue-stain fungi (*Ophiostoma* spp.) which hastens the death of trees and discolours the wood resulting in loss of timber grade and value.

BUGWOOD.ORG/G. CSOKA/1231222

Galleries created by Ips subelongatus

DISPERSAL AND INTRODUCTION PATHWAYS

Adult *Ips* beetles are capable of flying up to 4 km in search of suitable host material and they are also subject to wind dispersal. Transport of untreated larch wood can provide a means of introduction of immature stages and adults.

CONTROL MEASURES

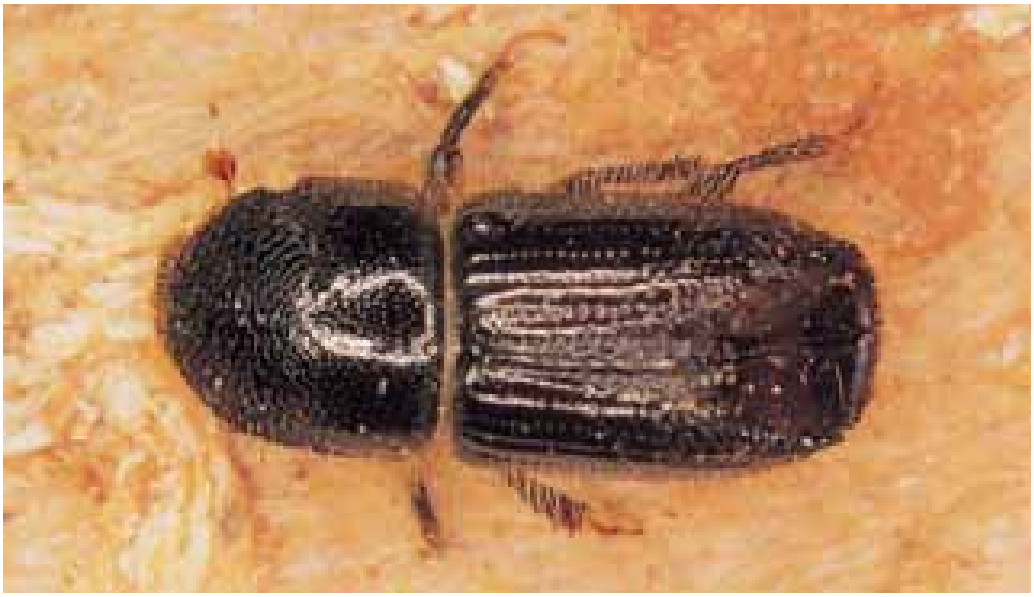
Control measures include silvicultural measures such as rapid removal and processing of infested trees, improving the resistance of forests, thinning, and treatments with chemical and biological preparations (EPPO, 2005). Biological control agents such as nematodes, microorganisms, parasitoids and predators may also play a role in regulating *I. subelongatus* populations. A forecasting system has been developed in China.

Since it is virtually absent from Europe with the exception of a small area in northeastern European Russia, *Ips subelongatus* was added to the EPPO A2 action list of pests recommended for regulation as quarantine pests in 2004. Recommended control measures include requiring imported *Larix* wood and bark to be from a pest-free area and debarking or kiln-drying wood and bark from infested areas. These requirements are also extended to the less important hosts of *Abies*, *Picea* and *Pinus* species.

Ips typographus

Other scientific names: *Dermestes typographus* Linnaeus, 1758; *Bostrichus octodentatus* Paykull, 1800; *Ips japonicus* Niijima, 1909; *Ips sexdentatus* Börner, 1776; *Tomicus typographus* Linnaeus, 1758
Order and Family: Coleoptera: Scolytidae
Common names: European spruce bark beetle; spruce beetle; spruce engraver beetle; eight-toothed spruce bark beetle

Ips typographus Linnaeus, 1758 is one of the most serious and destructive pests of spruce in its native range of Asia and Europe. It is common throughout the entire natural range of *Picea abies* in Europe and also occurs in plantations in Western Europe, outside the natural range of the host. Outbreaks have occurred in the Czech Republic, Germany, Italy, Norway, Poland, Slovakia and Sweden. This pest has caused excessive secondary damage in forests already damaged by other factors such as severe storms. *I. typographus* is a significant quarantine pest risk in North America where it has been intercepted at several locations.



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Adult European spruce bark beetle, Ips typographus

DISTRIBUTION

Native: Europe; Asia and the Pacific (northern)
Introduced: No records to date

IDENTIFICATION

Larvae are small, legless and whitish in colour with orange heads and the pupae are waxy white and approximately 4 mm long (Humphreys and Allen, 1999).

Adult beetles are cylindrical, reddish, dark brown or black in colour and approximately 4.2 to 5.5 mm long (EPPO/CABI, 1997; Kimoto and Duthie-Holt, 2006).

Long yellowish hairs cover the front of the head and the sides of the body. Both sexes have four spines on each side of the posterior portion of the forewings, with the third spine being the largest and enlarged at the tip (Kimoto and Duthie-Holt, 2006).

HOSTS

Picea spp., including *P. abies* (main host in Europe), *P. orientalis* and *P. yezoensis* (northern Asia); *Pinus* spp.; *Abies* spp.

BIOLOGY

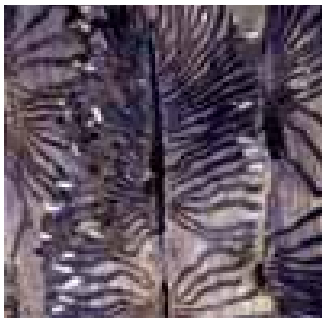
The European spruce bark beetle attacks both stressed and healthy trees in groups and overwhelms the defence mechanisms of host trees. During non-outbreak periods, the beetles breed in wind-felled trees, slash and logs while during outbreaks the beetles kill healthy trees (EPPO/CABI, 1997). Attacks are initiated by the males, who construct nuptial chambers under the bark, emit aggregation pheromones and are subsequently joined by 1 to 4 females (Kimoto and Duthie-Holt, 2006). The females construct egg galleries in the inner bark where they lay approximately 50 eggs on each side. Young larvae feed in larval galleries which radiate at right angles to the egg gallery and become wider as the larvae grow. Pupation takes place at the ends of the larval galleries. Young adult beetles maturation feed under the bark creating characteristic tunnels in the wood before emerging through round exit holes approximately 2 to 3 mm in diameter (Humphreys and Allen, 1999). The beetles generally overwinter in the adult stage, mainly in the forest litter near the tree where they developed but also under the bark of the host tree.

The number of generations per year and the timing of the life cycle depend on climate. At high altitude and latitude only one annual generation is produced while in the lowlands of Central Europe two generations are typical and even three generations per year at warmer sites (EPPO/CABI, 1997). Spring flight occurs when the air temperature rises to approximately 20 °C which generally occurs from April to June in different parts of its range. The flight for the second generation generally takes place in July or August but in northern areas, adults emerge from July to October and in central Europe emergence of the second generation may take place as late as November (EPPO/CABI, 1997).

SYMPTOMS AND DAMAGE

The needles of attacked conifers turn yellow-green to reddish-brown and eventually drop within a few weeks. Other signs of infestation include red-brown frass in bark crevices, the presence of round exit holes, and small pitch tubes extruding from the bark (Kimoto and Duthie-Holt, 2006). Woodpecker damage may also be evident.

As with other conifer bark beetle species, *Ips typographus* is a vector for blue-stain fungi (*Ophiostoma* spp., *Ceratocystis polonica*) which hastens the death of trees, discolours the wood and can result in loss of timber grade and value.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Extensive gallery systems, blue-stained wood and round exit holes indicate attack by Ips typographus

DISPERSAL AND INTRODUCTION PATHWAYS

Adult *Ips* beetles are capable of flying up to 4 km in search of suitable host material and they are also subject to wind dispersal. Transport of unprocessed logs, wood products or wooden packing materials, dunnage or pallets containing bark strips can provide a means of introduction of immature stages and adults.

CONTROL MEASURES

The most effective control measure against damage by *Ips typographus* is to remove infested trees and all potential breeding materials such as weakened trees, windthrows and logs with bark before the new generation of adult beetles emerge. Silvicultural techniques aimed at increasing the stability and vitality of forest stands is also recommended. The use of pheromone-baited traps or trap trees has also been successfully used to trap and suppress beetle populations and prevent outbreak conditions.

As this pest is of major quarantine importance, debarking of logs before export is the best and likely only efficient way to prevent it from being introduced into new areas.

G. ALLARD

Pheromone traps have been used to help control Ips typographus *in Slovakia*

Leptocybe invasa

Order and Family: Hymenoptera: Eulophidae
Common names: blue gum chalcid

The blue gum chalcid, *Leptocybe invasa* Fisher & LaSalle, 2004, is a newly described insect that is a major pest of young eucalypt trees and seedlings. Believed native to Australia, it is currently spreading through Africa, Asia and the Pacific, Europe and the Near East. Information on the taxonomy, distribution, biology and economic impacts of the blue gum chalcid are still being investigated.

Z. MENDEL

Adult female Leptocybe invasa

DISTRIBUTION

Native: believed native to Australia (Asia and the Pacific) although its distribution there is still unknown.
Introduced: Africa: Algeria, Kenya (2002), Morocco, South Africa (2007), the United Republic of Tanzania (2005), Uganda (2002)
Asia and the Pacific: India, New Zealand, Thailand, Viet Nam
Europe: France, Italy, Portugal, Spain, Turkey
Near East: Islamic Republic of Iran, Israel, Jordan, the Syrian Arab Republic

IDENTIFICATION

The female chalcid is a small wasp, brown in colour with a slight to distinctive blue to green metallic shine (TPCP, 2005). The average length is 1.2 mm. With the exception of one record describing males in Turkey, only females of this species, which reproduce by parthenogenesis, have been observed (EPPO, 2008). Larvae are minute, white and legless.

HOSTS

The blue gum chalcid has a relatively narrow host range attacking eucalypt species (Mendel *et al*., 2004). Suitable host species include *Eucalyptus saligna*, *E. grandis*, *E. deanei*, *E. globulus ssp. globulus*, *E. nitens*, *E. botryoides*, *E. camaldulensis*, *E. gunnii*, *E. robusta*, *E. bridgesiana*, *E. viminalis* and *E. tereticornis*.

BIOLOGY

Attacks take place within 1 to 2 weeks of bud break. Eggs are laid in the epidermis of the upper sides of newly developed leaves, on both sides of the midrib, in the petioles and in the parenchyma of twigs (TPCP, 2005; EPPO, 2008). White minute, legless larvae develop within the host plant. Five stages of gall development have been recorded on *E. camaldulensis* in Israel (TPCP, 2005).

- The first symptoms of cork tissue appearing at the egg insertion spot begin one to two weeks after oviposition. A small change in the morphology of the attacked tissue is evident, the cork scar becomes bigger and the section of the midrib that carries the eggs often changes colour from green to pink.
- The typical bump shape of the galls develops and they reach their maximum size of about 2.7 mm wide.
- The green surface colour fades and tends to become pink while retaining its typical gloss.
- Glossiness of the gall surface is lost and its colour changes to light or dark red depending on whether the galls are present on leaves or stems.
- The galls change colour to light brown on leaves and red on stems. Emergence holes of the adult wasps are evident.

Two to three overlapping generations per year have been observed in the Islamic Republic of Iran, Israel and Turkey (Mendel *et al.*, 2004).

Z. MENDEL

Ovipositing female Leptocybe invasa

SYMPTOMS AND DAMAGE

The developing larvae form bump-shaped galls on the leaf midribs, petioles and stems of new growth of young eucalypt trees, coppice and nursery seedlings. Severely attacked trees show leaf fall, gnarled appearance, loss of growth and vigour, stunted growth, lodging, dieback and eventually tree death (Mendel *et al*., 2004).

During outbreaks wasp pressure is quite intensive and all new growth may be damaged. While the impact of the wasp on mature tree development is not yet clear, galls can be found on most leaves if the wasp occurs in large numbers (TPCP, 2005).

Damage caused by Leptocybe invasa *on eucalypt branches and leaf petioles, Kibaha, the United Republic of Tanzania. Left: young galls; right: older galls with exit holes*

DISPERSAL AND INTRODUCTION PATHWAYS

Possible pathways of introduction include movement of nursery stock. The adult wasps are very small and are thus incapable of long distance flight.

CONTROL MEASURES

There are currently no control measures for *Leptocybe invasa* although research on possible biological control agents is ongoing in Australia and Israel.

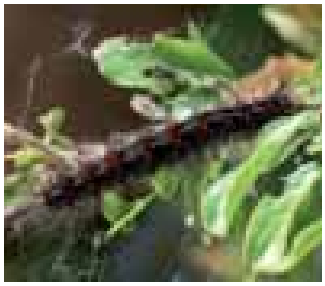
Aprostocetus sp., *a natural enemy of* Leptocybe invasa, *recently released in Israel*

Lymantria dispar

Other scientific names: *Porthetria dispar* Linnaeus; *Ocneria dispar* Linnaeus; *Bombyx dispar* Linnaeus; *Hypogymna dispar* Linnaeus; *Liparis dispar* Linnaeus; *Phalaena dispar* Linnaeus; *Porthesia dispar* Linnaeus
Order and Family: Lepidoptera: Lymantriidae
Common names: gypsy moth; Asian gypsy moth; European gypsy moth

The gypsy moth, *Lymantria dispar* Linnaeus, 1758, is a significant defoliator of a wide range of broadleaf and even conifer trees. While low population levels can exist for many years without causing significant damage, severe outbreaks can occur resulting in severe defoliation, growth loss, dieback and sometimes tree mortality. Two strains of gypsy moth exist: the Asian strain, of which the female is capable of flight; and the European strain, of which the female is flightless. This moth is considered a significant pest in both its native and introduced ranges.


G. ALLARD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Gypsy moth egg masses, larva and adults

DISTRIBUTION

Native: The Asian strain is native to southern Europe, northern Africa, Asia and the Pacific (central and southern, and Japan).
The European strain is found in temperate forests throughout Western Europe.
Introduced: The European strain has been introduced to North America, in Canada (1912 first detected, 1924 first infestation) and the United States (1869).
The Asian strain has been introduced into Europe (Germany, other countries in the region) where it readily hybridizes with the European strain. A breeding colony was reported in 1995 in Europe (United Kingdom) but there was no establishment. This strain has been introduced but has not established in North America (Canada, United States) (Wallner, 2000a).

IDENTIFICATION

The Asian gypsy moth is virtually identical in appearance to its European counterpart (Wallner, 2000a). Adult females are white or cream in colour and are much larger than the males with a wingspan of 55 to 70 mm (Wallner, 2000a; Kimoto and Duthie-Holt, 2006). Adult males are mottled brown in colour and have a wingspan of 35 to 40 mm (Wallner, 2000a; Kimoto and Duthie-Holt, 2006). Both sexes have a dark, crescent-shaped mark on the forewing and pectinate antennae, although the longer branches on the males give their antennae a feathered appearance (Kimoto and Duthie-Holt, 2006).

Egg masses are ovoid, 3 to 6 cm in length and 2 to 3 cm in width, and can contain 100 to 1 000 eggs (Wallner, 2000a). They are covered in tan coloured hairs from the female's abdomen and eventually become sun bleached with age (Brandt, 1994; Kimoto and Duthie-Holt, 2006). Spent egg masses have small pin-sized holes created by emerging larvae.

Newly hatched larvae are 3 mm in length and tan in colour but turn black within 24 hours (Wallner, 2000a). The first and third instars are black with long hairs while the second instar is brown with short hairs (Kimoto and Duthie-Holt, 2006). The fourth, fifth and sixth instars are quite similar to each other and may be light to dark gray with flecks of yellow. They have long dark or golden hairs and two rows of tubercles along the back which are typically arranged in five pairs of blue tubercles followed by six pairs of red, but variations are known to occur (Kimoto and Duthie-Holt, 2006). Mature larvae are approximately 50 to 90 mm in length (Wallner, 2000a).

HOSTS

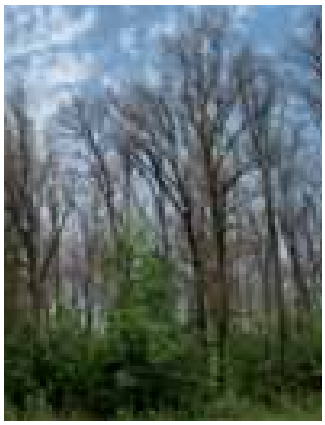
Both strains have exceptionally wide host ranges, more than 250 species, although the Asian strain is even broader than the European strain. Preferred hosts of both forms include *Quercus*, *Populus*, *Salix*, *Tilia*, *Betula* and *Malus* species. *Larix*, *Ulmus* and *Diospyros* species are also highly preferred. Conifers growing in mixture with preferred hosts can also be defoliated during periods of high insect pest densities (Wallner, 2000a).

BIOLOGY

Both the Asian and European strains of the gypsy moth have one generation per year. Adults are active in July and August when mating and egg-laying occur (Wallner, 2000a). Adult females of Asian strains are capable of flight whereas females of European strains are flightless. Females lay egg masses indiscriminately on almost any surface including tree bark, branches, rock piles, lawn furniture, birdhouses, wood piles, logs, recreational vehicles and equipment.

Larvae hatch in early May and climb to the tree tops and balloon on silken threads to neighboring trees where they feed gregariously (Wallner, 2000a). Male gypsy moth larvae typically pass through five instars while females have six instars (Wallner, 2000a). Early instar larvae excavate small holes in leaves and as the larvae grow they make larger holes and consume the leaf margins; final instar larvae consume the entire leaf (Kimoto and Duthie-Holt, 2006). They are primarily nocturnal feeders and rest in protected locations such as bark flaps, holes and wounds on host trees during the day.

Pupation takes place in sheltered places; pupae may be found attached by silken thread to branches, tree trunks, rocks, forest debris, buildings or fences (Kimoto and Duthie-Holt, 2006). Adults emerge approximately two weeks later.



Defoliation of trees by the gypsy moth in Romania (L) and Kyrgyzstan (R)

SYMPTOMS AND DAMAGE

Populations of the gypsy moth can occur at low levels in forests for many years without causing significant damage. However, at times there are significant outbreaks, frequently coinciding with periods when the trees are under stress such as in Central Europe in the 1990s. These outbreaks cause severe defoliation of host trees resulting in growth loss, dieback and sometimes tree mortality. Tree mortality often occurs when there are several sequential outbreaks. Outbreaks typically last for about three years and collapse when host trees are weakened to the point that they produce little or no foliage for the larvae to feed upon in the following spring. High levels of parasitism can also cause outbreaks to collapse.

DISPERSAL AND INTRODUCTION PATHWAYS

Adults of Asian strains are capable of flight and thus have strong dispersal ability whereas females of European strains are flightless. Young larvae can move some distance by ballooning from the tops of trees.

Pathways of introduction of the gypsy moth include movement of vehicles, camping equipment, nursery stock, ships, and equipment that has been exposed for a period to the outdoors. Ecotourism may contribute to ignorant or passive possession and dispersal and thus awareness campaigns are important.

CONTROL MEASURES

Preventative measures include thinning of forest stands to improve tree vigour and thinning to reduce the proportion of preferred host trees. Small infestations of gypsy moths particularly on ornamental trees can be controlled by collecting and destroying the egg masses before the eggs hatch (Brandt, 1994). Mass-trapping through the use of pheromones can also assist with control.

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Aerial spraying operations using Bacillus thuringiensis *var* kurstaki *(Btk) (Foray 76B) for gypsy moth control, United States*

Aerial and ground application of biological insecticides is the most common method for eradicating new isolated populations and also to suppress outbreaks of well established populations. The most common biological insecticide used against the gypsy moth is *Bacillus thuringiensis* (Bt) which disrupts the digestive system of larvae, suppressing their appetites and eventually resulting in death typically within 7 to 10 days. In the United States the gypsy moth is considered the most costly of introduced forest insect pests with annual control expenditures exceeding US$35 million since 1980 (Wallner, 2000a).

A number of natural predators have been used to control *L. dispar*. Vertebrate predators are important in maintaining low densities, parasites are often abundant during outbreaks, and diseases, especially a nucleopolyhedrosis virus, have been noted to be responsible for the collapse of outbreak populations (Wallner, 2000a). Another important natural control is the fungal pathogen, *Entomophaga maimaiga*, which is not dependent on gypsy moth density (Wallner, 2000a).

Predictive models have been used to determine risk assessment and potential damage in new areas.

Lymantria monacha

Other scientific names: *Psilura monacha* Linnaeus; *Liparis monacha* Linnaeus; *Ocneria monacha* Linnaeus; *Phalaena monacha* Linnaeus; *Porthetria monacha* Linnaeus; *Bombyx monacha* Linnaeus, 1758; *Noctua heteroclita* Müller, 1764; *Bombyx eremita* Hübner, 1808; *Bombyx nigra* Freyer, 1833; *Liparis monacha* var. *oethiops* De Selys-Longchamps, 1857; *Psilura transiens* Thierry Mieg, 1886; *Lymantria transiens* Lambillion, 1909; *Lymantria monacha flaviventer* Kruilikovsky; *Lymantria monacha gracilis* Kruilikovsky; *Lymantria fasciata* Hannemann, 1916; *Lymantria kusnezovi* Kulossow, 1928; *Lymantria brunnea* Stipan, 1933; *Lymantria monacha chosenibia* Bryk; *Lymantria monacha matuta* Bryk; *Lymantria monacha idae* Bryk; *Lymantria monacha lateralis* Bryk; *Lymantria monacha eremita*; *Lymantria monacha nigra*
Order and Family: Lepidoptera: Lymantriidae
Common names: nun moth; tussock moth; black arches moth; black-arched tussock moth

Lymantria monacha Linnaeus, 1758 is a major pest of broadleaved and coniferous trees in Europe and Asia. Defoliation by nun moth larvae can kill host trees especially conifers and has caused extensive losses despite intervention with biological and chemical insecticides. In parts of Europe, the occurrence of outbreaks has increased possibly as a result of the establishment of extensive pine plantations in poor quality areas. A serious outbreak was recorded in Europe between 1978 and 1985 and again in 1992 in Poland which involved hundreds of thousands of hectares.

Lymantria monacha *larva and adults (female and male)*

DISTRIBUTION

Native: Asia and the Pacific; Europe
Introduced: No records to date

IDENTIFICATION

Adult nun moths are moderately sized, hairy and often stout-bodied. Their forewings are white with numerous black, transverse, wavy lines and patches and the hind wings are greyish, with dark patches along the outer edge (Humphreys and Allen, 2002). Black and grey-brown forms occasionally occur. Females have a reddish-brown abdomen with black bands, short saw-like antennae, an extremely long extensible ovipositor and a wingspan of 45 to 55 mm (Humphreys and Allen, 2002; Kimoto and Duthie-Holt, 2006). Males have a grey-black abdomen, feathery antennae and a wingspan of 35 to 45 mm (Wallner, 2000b; Kimoto and Duthie-Holt, 2006).

Pupae are stout, shiny reddish-brown with light-coloured hair, and approximately 18 to 25 mm in length (Humphreys and Allen, 2002).

Newly hatched larvae are approximately 4 mm long and tan in colour though they turn black within 24 hours (Wallner, 2000b). Mature larvae are 30 to 40 mm long, light to dark brown with an orange to pale-brown head with black markings (Wallner, 2000b; Kimoto and Duthie-Holt, 2006). The first four abdominal segments have a dorsal pair of small, bluish glandular protrusions, the sixth and seventh segments have prominent mid-dorsal, orange glandular warts, and a dark dorsal band runs from the second to the eleventh segment (Kimoto and Duthie-Holt, 2006). Numerous short black and white hairs are present; hairs on the prothoracic and anal segments are longer.

Eggs are round, slightly concave in the centre, one millimetre in diameter, and initially orange-brown or purple in colour, turning dark brown over time (Kimoto and Duthie-Holt, 2006). They are laid in masses in bark crevasses of host trees and cannot be seen unless the outer bark is peeled away (Wallner, 2000b).

HOSTS

Species of *Pinus, Picea, Larix* and *Abies* are preferred hosts but the nun moth will also feed on many broadleaf trees including *Acer, Betula*, *Carpinus*, *Fagus*, *Fraxinus*, *Malus*, *Prunus*, *Quercus* and *Ulmus* species and other fruit trees. Host tree preference varies between areas.

BIOLOGY

Nun moth has one generation per year. Both male and female adults are strong fliers and are active for 3 to 5 weeks between July and September when they mate and deposit eggs (Wallner, 2000b). Females lay masses of 70 to 300 eggs, typically in bark crevices. However they will also lay on any hard surface such as motor vehicles. They overwinter as eggs and hatch in spring. Newly hatched larvae feed on young foliage, often towards the top of trees, while older larvae feed on older foliage. Larvae develop through five to seven instars depending on host type and health, weather and other factors (Wallner, 2000b). Pupation usually occurs in July on the tree trunks, but when populations are high, pupae can also be found high in tree crowns. Adults emerge in mid-summer; females live approximately 10 days while males may live up to 24 days after emerging (Wallner, 2000b).

SYMPTOMS AND DAMAGE

Nun moth larvae feed on needles or leaves and can severely defoliate host trees resulting in tree mortality. They tend to attack monoculture stands of trees that are growing in poor conditions. The nun moth can decimate vast areas of forest and increase the risk of attack by other insects such as bark beetles. Outbreaks last for approximately five years in pine forests and seven years in spruce forests (Humphreys and Allen, 2002).

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*Heavy defoliation of Norway spruce (*Picea abies*) stands in the Czech Republic by the nun moth*

On conifer host trees, young larvae feed on the foliage of newly expanded shoots whereas older larvae are able to feed on more mature foliage but still prefer new needles. They can be wasteful feeders, eating only the base of a needle which results in partially uneaten needles falling to the ground. Defoliated trees exhibit thinned crowns and are reddish-brown in colour (Kimoto and Duthie-Holt, 2006). During outbreaks, over 50 percent of the foliage can be defoliated and successive years of severe defoliation can cause tree mortality (Kimoto and Duthie-Holt, 2006). On broadleaved host trees, larval feeding initially creates holes in the leaves. As feeding progresses, however, entire leaves are consumed except for the middle vein (Kimoto and Duthie-Holt, 2006).

DISPERSAL AND INTRODUCTION PATHWAYS

Adults are strong fliers and can spread fair distances, males have been known to disperse up to 3.5 km, and young larvae can balloon from tree tops. Eggs may also be transported on logs, ships or vehicles. Since egg masses are typically deposited in bark crevices of host trees, long distance transport of this species could be facilitated by the movement of unprocessed logs and crates, pallets or dunnage containing large strips of bark.

CONTROL MEASURES

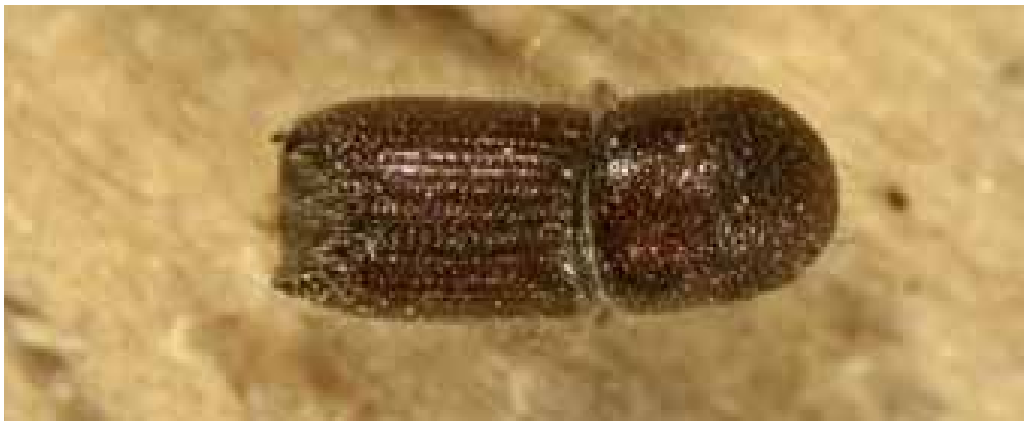
Nun moth has a number of natural enemies including parasitoids, predators and disease (Wallner, 2000b). Birds have been known to help control egg and larval stages and a baculovirus has also been implicated in population collapses and has been cultured and applied for control (Wallner, 2000b).

Pheromone trapping can be used both for detection purposes and as a means of disrupting mating (Humphreys and Allen, 2002). Direct control with biological insecticides, such as *Bacillus thuringiensis*, can be effective over large areas.

Orthotomicus erosus

Other scientific names: *Bostrichus duplicatus* Ferrari; *Bostrichus laricis* Perris; *Ips erosus* Wollaston; *Ips erosus* var. *robustus* Knotek; *Tomicus erosus* Wollaston; *Tomicus rectangulus* Eichoff
Order and Family: Coleoptera: Scolytidae
Common names: Mediterranean pine engraver beetle; European bark beetle; Mediterranean pine beetle

Orthotomicus erosus Wollaston, 1857 is a bark beetle that can kill pines particularly those planted at low elevations and on dry sites. It is usually considered a secondary pest infesting fallen and stressed trees and is often found in association with other forest pests. Its successful introduction into countries outside its native range has lead to some concern, particularly in regions with significant areas of pine plantations.



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Adult Mediterranean pine engraver beetle, Orthotomicus erosus

DISTRIBUTION

Native: Northern Africa (Morocco); Asia and the Pacific; Europe
Introduced: Africa: South Africa, Swaziland (early 1980s)
Asia and the Pacific: Fiji
Europe: Finland, Sweden, United Kingdom
Latin America and the Caribbean: Chile (1986 not now detected)
Near East: Tajikistan
North America: United States (2004)

IDENTIFICATION

Adult beetles averages 2.7 to 3.8 mm length and are reddish-brown in colour (Cavey, Passoa and Kucera, 1994; Eglitis, 2000). The head is covered by a thoracic shield and is not visible when viewed dorsally. The posterior portion of the forewings is concave with four lateral spines; the second spine is the broadest and most conspicuous (Eglitis, 2000).

Larvae are white or cream-coloured, legless grubs with amber heads and are approximately 5 mm long when mature (Eglitis, 2000).

HOSTS

Orthotomicus erosus primarily attacks pine species such as *Pinus armandii*, *P. brutia*, *P. brutia* var. *eldarica*, *P. brutia* var. *pityusa*, *P. canariensis*, *P. caribaea*, *P. coulteri*, *P. echinata*, *P. kesiya*, *P. massoniana*, *P. mugo* subsp. *uncinata*, *P. nigra*, *P. nigra* ssp. *pallasiana*, *P. patula*, *P. pinaster*, *P. pinea*, *P. radiata*, *P. strobus*, *P. sylvestris*, *P. tabulaeformis* and *P. yunnanensis*. It will attack other conifer species such as *Pseudotsuga menziesii* and *Picea*, *Abies* and *Cedrus* species but it is believed to breed only in pines.

BIOLOGY

The Mediterranean pine engraver typically attacks recently fallen or cut pine trees and branches, but it can colonize and kill standing trees especially those stressed by drought, fire or wind (Haack, 2004). They generally breed in the rough-barked sections of the main trunk and in branches larger than 5 cm in diameter (Eglitis, 2000). Smooth-barked portions of host trees are primarily used for maturation feeding.

Attacks are initiated by males that bore through the bark to the phloem-cambium layer where they construct a nuptial chamber. They emit aggregation pheromones and are soon joined by one to three females, each of which mates with the male and then constructs an individual egg gallery from the nuptial chamber, parallel to the grain of the wood (Eglitis, 2000). Females typically lay 26 to 75 eggs in niches along the sides of the galleries (Eglitis, 2000; Lee, Smith and Seybold, 2005). The eggs hatch and the larvae feed in the phloem causing a distinctive engraving pattern; they develop through three instars expanding the tunnels as they feed (Lee, Smith and Seybold, 2005). When the larvae are ready to pupate, they tunnel towards the bark particularly if the phloem of the host tree is thick (Lee, Smith and Seybold, 2005).

Adult beetles maturation feed beneath the bark of the brood host or in another suitable host tree, sometimes of a different species (Eglitis, 2000; Haack, 2004). Between mid-October and December, they aggregate under the bark of host trees to overwinter. Small round exit holes measuring approximately 1.5 mm in diameter are apparent in the outer bark of host trees after adults emerge (Lee, Smith and Seybold, 2005). Adult beetle flight can occur through a broad temperature range of 14 to 38 °C; in Israel, the threshold for flight is even lower during winter (12 °C) (Eglitis, 2000).

The Mediterranean pine engraver completes two to seven generations per year in different parts of its range, depending on local temperatures and host quality (Haack, 2004). Two generations per year are typical in Turkey, France and Morocco, three to four generations are observed in Tunisia and South Africa, and three to five in Israel (Lee, Smith and Seybold, 2005).

SYMPTOMS AND DAMAGE

The Mediterranean pine engraver is usually a secondary bark beetle that infests recently fallen trees, broken branches, slash, and standing trees that have been wounded or are stressed from a variety of factors such as fire or drought (Eglitis, 2000; Lee, Smith and Seybold, 2005). Attacks on stressed trees frequently leads to death of the tree.

The most conspicuous indication of attack by *Orthotomicus erosus* is the fading of foliage of infested host trees from green to yellow to reddish brown (Eglitis, 2000). Small entrance holes with frass pushed out and exit holes may be visible on the bark surface, especially on smoother bark surfaces; entrance and exit holes may be difficult to detect on rough-barked regions of the tree (Lee, Smith and Seybold, 2005). If vigorous trees are attacked, pitch tubes may be found in the bark crevices (Eglitis, 2000). Inspection of the underside of the bark of declining pines may reveal a dense network of galleries (Lee, Smith and Seybold, 2005). These galleries typically consist of a nuptial chamber and one to five longitudinal egg galleries but may vary depending on host type and location (Eglitis, 2000).

Galleries created by the Mediterranean pine engraver beetle

This beetle is often found in association with other forest pests including *Carphoborus minimus*, *Hylastes angustatus*, *Hylurgus ligniperda*, *Matsucoccus feytaudi, Pityogenes calcaratus*, *Pissodes nemorensis*, *Tomicus destruens* and *T. minor* (Eglitis, 2000). As with other conifer bark beetle species, *Orthotomicus erosus* is a vector for a number of wood-staining or blue-stain fungi which hastens the death of trees, discolours the wood and can result in loss of timber grade and value.

DISPERSAL AND INTRODUCTION PATHWAYS

Adult beetles are capable of flying considerable distances in search of suitable hosts and are also subject to wind dispersal (Eglitis, 2000). All life stages of the Mediterranean pine engraver can be easily transported on wood packing materials, particularly those made from pine and containing bark strips. Prior to the implementation of ISPM No. 15, this pest was commonly intercepted on wood packing materials such as crates and pallets since it often attacks recently cut trees which are typically converted into such materials (Haack, 2004).

CONTROL MEASURES

Preventative measures that involve good sanitation, limiting movement of recently cut pine branches and stems, keeping standing trees healthy and vigourous and early detection of infestations are the best defence against the Mediterranean pine engraver (Lee, Smith and Seybold, 2005). Proper care and watering of standing trees can reduce the probability of an outbreak since these beetles are known to primarily attack living trees under stress. It is recommended that managers avoid piling any pine material next to live trees and that they chip, burn or debark freshly cut pine material or for small quantities of pine material, completely cover them with thick, clear plastic sheeting in a sunny location (Lee, Smith and Seybold, 2005).

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Pinus brutia *killed by the Mediterranean pine engraver beetle, Cyprus*

The Mediterranean pine engraver has several known natural enemies. The Syrian woodpecker (*Picoides syriacus*) has been observed feeding on the beetle in Israel (Lee, Smith and Seybold, 2005). In South Africa, the larvae are parasitized by wasps, such as *Dendrosoter caenopachoides* and *Metacolus unifasciatus*, and eaten by several predatory beetles including *Alulonium ruficorne*, *Corticeus pini* and *Platysoma oblongum* and the predatory bug *Lyctoris* sp. (Lee, Smith and Seybold, 2005). A parasitoid, *Dendrosoter caenopachoides*, was reared and released in South Africa and it has since established (Eglitis, 2000).

Phoracantha recurva and *Phoracantha semipunctata*

***Phoracantha recurva* Newman, 1840**
Order and Family: Coleoptera: Cerambycidae
Common names: eucalyptus longhorned borer; eucalyptus borer; longicorn beetle; yellow phoracantha borer; yellow longicorn beetle

***Phoracantha semipunctata* Fabricius, 1775**
Order and Family: Coleoptera: Cerambycidae
Common names: eucalyptus longhorned borer; common eucalypt longhorn; common eucalypt longicorn; eucalypt longhorn; eucalyptus borer; longicorn beetle; blue gum borer; firewood beetle

Phoracantha recurva and *Phoracantha semipunctata* are both serious borer pests of eucalypts, particularly those planted outside their natural range. In their native Australia they are considered minor pests attacking damaged, stressed or newly felled trees but they have become established in many temperate and tropical regions worldwide where they have been known to kill even healthy trees.


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Phoracantha recurva *(L) and* Phoracantha semipunctata *(R)*

DISTRIBUTION

Phoracantha recurva
Native: Asia and the Pacific: Australia
Introduced: Africa: Malawi, Morocco, South Africa, Tunisia (1999), Zambia
Asia and the Pacific: New Zealand, Papua New Guinea
Europe: Greece (one record), Spain (1998)
Latin America and the Caribbean: Argentina (1997), Brazil (2001), Chile (1997), Uruguay (1998)
North America: United States (1995)

Phoracantha semipunctata
Native: Australia

Introduced: Africa: Algeria (1972), Egypt (1950s), Libyan Arab Jamahiriya (1998), Morocco (1962), Tunisia (1962)
Europe: Canary Islands (1991), France (1984), Italy (around 1969), Netherlands (detected but believed eradicated), Portugal (1980), Spain (1980), Turkey (1959)
Latin America and the Caribbean: Brazil (1994)
Near East: Cyprus (around 1967), Israel (1940s), Lebanon (1950s)
North America: United States (California, 1980s)

IDENTIFICATION

Adult eucalyptus longhorned borers are approximately 14 to 30 mm long and have shiny, dark brown and yellow to cream-coloured areas on their wing covers (University of California, 2000). Antennae are as long as or longer than the body and the antennae of males have prominent spines.

Adults of both species are very similar to one another although there are differences in wing cover colour and hairs and spines on antennae (University of California, 2000). *Phoracantha semipunctata* has wing covers that are mostly dark brown with a zigzag line bisecting the cream-coloured area in the middle whereas the wing covers of *P. recurva* are mostly cream to yellowish in colour with dark brown areas primarily limited to the posterior end. Long, dense golden hairs can be found on the underside of each antenna segment on *Phoracantha recurva*; such hairs are either absent or sparse on *P. semipunctata*.

Mature larvae are cream-coloured, legless and may be more than an inch in length (University of California, 2000). Eggs are ovoid and pale yellow in colour.

HOSTS

Eucalyptus species

BIOLOGY

Female beetles are attracted to stressed trees or freshly cut wood where they lay eggs in groups under loose bark. The larvae tunnel under the bark and into the cambium layer and effectively ring bark the host trees. The larval feeding can rapidly kill the trees or cause significant damage to the timber of affected trees. Larvae take 2 to 6 months to develop depending on the moisture conditions in the logs. Pupation takes place in pupal chambers. Adults live for several weeks.

SYMPTOMS AND DAMAGE

Phoracantha species tend to attack damaged or stressed trees; vigorous, well-watered trees are rarely attacked though it does occur.

The presence of holes in the bark and stains or oozing liquid on limbs or trunks are common symptoms of longhorned borer attack (University of California, 2000). Foliage may also discolour and wilt, and limbs may dieback.

The feeding by larvae and resulting galleries created within host trees can girdle trees killing them. Such trees are characterized by a thin canopy with wilted or dry leaves and cracked bark packed with frass (University of California, 2000). Infested trees are often killed in a matter of a few weeks and resprouting may occur from the tree base.

DISPERSAL AND INTRODUCTION PATHWAYS

Adults are moderately long-lived and are strong fliers that are thus capable of naturally dispersing a fair distance. Dispersal over greater distances occurs through movement of nursery stock and freshly cut wood with high moisture content. Introduction into southern Africa is believed to have been through the importation of infested railway sleepers.

CONTROL MEASURES

The same management and control methods are applied to both *Phoracantha* species and are based on good cultural practices and biological control. Such practices involve reducing tree stress through irrigation and protection against injury, planting resistant or tolerant eucalypt species and avoiding activities that disrupt biological control (University of California, 2000).

Properly handling eucalyptus wood is also effective in controlling borer populations (University of California, 2000). Since moist wood is most suitable for ovipositing beetles, methods such as cutting and splitting wood to hasten the drying of the wood helps to reduce the length of time the wood can support beetle development. Bark can be removed from felled logs or the wood can be solarized by placing it in a sunny location for 10 to 12 weeks and covering it with ultraviolet-resistant plastic which prevents new beetles from attacking and resident beetles from emerging and spreading to standing hosts nearby. Infested eucalypt trees, branches and wood should be treated or destroyed by burying, burning or chipping.

Chemical insecticides are not considered suitable or effective for the management of eucalyptus longhorned borer populations.

Biological control with natural enemies is possibly the best solution to controlling longhorned borer populations. At low beetle population levels, natural enemies may be better able to keep populations in check and vigorous trees can survive a few attacks. Some examples of biological control agents for *Phoracantha* species include the Australian parasitic wasps *Avetianella longoi*, *Callibracon limbatus*, *Jarra maculipennis*, *J. phoracantha* and *Syngaster lepidus*, and *Helcostizus rufiscutum* from California (University of California, 2000). Felled trap trees with bark are used to deliver the natural enemies and to attract gravid females.

Sirex noctilio

Other scientific names: *Sirex melanocerus* Thomson, 1871; *Paururus noctilio*
Order and Family: Hymenoptera: Siricidae
Common names: European woodwasp; sirex; sirex woodwasp; steel-blue horntail

Sirex noctilio Fabricius, 1793 is a major global threat to forests and the forest sector causing considerable damage and costs for control. In 1900, this pest was reported from New Zealand which represented the first time it was recorded outside of its native range. Since then it has gradually spread around the globe – to Australia in the 1960s, Latin America and the Caribbean in the 1980s, Africa in the 1990s and North America in this decade.


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Adult sirex woodwasps: male (L); female (R)

DISTRIBUTION

Native: Africa (northern: Algeria, Morocco, Tunisia); Asia and the Pacific, Europe
Introduced: Africa: South Africa (1994)
Asia and the Pacific: Australia (1961), New Zealand (1900), Tasmania (1952)
Latin America and the Caribbean: Argentina (1985), Brazil (1988), Chile (2001), Uruguay (1980)
North America: Canada (2005), United States (2004)

IDENTIFICATION

Eggs are cylindrical, creamy white and approximately 0.30 to 0.35 mm wide and 1.35 to 1.56 mm long (Ciesla, 2003b). Larvae are creamy white in colour, legless with a distinctive dark spine at the posterior end (TPCP, n.d.). Length varies but larvae can reach up to 30 mm in length.

Adult wasps are metallic blue-black in colour with two pairs of clear yellow membranous wings, black antennae and an upturned, spear-shaped spine or plate (cornus) at the end of the abdomen (TPCP, n.d.; Walker, 2006). They are large, robust insects ranging in size from 10 to 44 mm in length (Walker, 2006). Females are uniform in colour with a prominent robust ovipositor located beneath the cornus, orange legs and black feet (Haugen and Hoebeke, 2005; Walker, 2006). Smaller than the female, the male wasp has orange middle abdominal segments and orange legs except for the hind legs which are thickened and black (Haugen and Hoebeke, 2005; Walker, 2006).

HOSTS

Sirex noctilio has a wide host range and is primarily a pest of *Pinus* spp. such as *P. attenuata*, *P. banksiana*, *P. brutia*, *P. canariensis*, *P. caribaea*, *P. contorta*, *P. densiflora*, *P. echinata*, *P. elliottii*, *P. halepensis*, *P. jeffreyi*, *P. kesiya*, *P. muricata*, *P. nigra*, *P. nigra austriaca*, *P. nigra calabrica*, *P. palustris*, *P. patula*, *P. pinaster*, *P. pinea*, *P. ponderosae*, *P. radiata*, *P. resinosa*, *P. strobus*, *P. sylvestris* and *P. taeda* (Carnegie *et al*., 2006; USDA-APHIS, 2007). *Pinus radiata, P. taeda* and *P. patula* are particularly susceptible (Carnegie *et al*., 2006). Species of *Abies*, *Larix*, *Picea* and *Pseudotsuga*, particularly *Pseudotsuga menziesii*, have also been attacked (USDA-APHIS, 2007).

BIOLOGY

The sirex woodwasp attacks living pines and is particularly attracted to stressed or dying trees with low sap pressure. The adult female drills into the wood of trees using her ovipositor, depositing eggs (20 to 500) as well as toxic mucus and a fungus (*Amylostereum areolatum*) which effectively kill the host tree (Hurley, Slippers and Wingfield, 2007). The movement of water and sugars within the tree trunk is impeded by the mucus causing foliage to wilt and creating suitable conditions for the fungus (Matthews, 2005). *Amylostereum areolatum* relies on *S. noctilio* for dispersal and inoculation into trees and the wasp larvae rely on the fungus for wood breakdown and food (USDA-APHIS, 2007).

Unfertilized eggs develop into males whereas fertilized eggs produce females (Haugen and Hoebeke, 2005). Larvae can hatch as early as nine days after oviposition and can remain dormant for several months, particularly in cooler climates (Ciesla, 2003b). They feed in the wood, constructing large galleries and thus degrading wood quality. Once feeding is complete, the larvae enter prepupal and pupal stages; pupation lasts 16 to 21 days (Ciesla, 2003b). Adult wasps bore their way out of host trees leaving perfectly round exit holes. Males emerge before the females. The lifespan of adult woodwasps can be up to 12 days, but females that have deposited all their eggs may only live for three to four days (Ciesla, 2003b). Each generation takes between ten months and two years, the latter primarily in cooler climates.


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Damage caused by Sirex noctilio

SYMPTOMS AND DAMAGE

Resin droplets and oviposition scars on the bark of trees are the first signs of infestation by sirex (Ciesla, 2003b). Tree crowns and foliage wilts and turns from green to yellow to reddish brown. Larvae tunnel in the wood creating galleries full of very fine frass, which significantly damages the wood. Round exit holes, approximately 3 to 8 mm in diameter, appear when the adult insects emerge.

DISPERSAL AND INTRODUCTION PATHWAYS

Sirex noctilio can spread naturally through flight and wind dispersal. Adults are strong fliers capable of traveling several kilometers in search of suitable host trees. For example, in southwestern South Africa the dispersal rate of *S. noctilio* has been estimated at 48 km per year and rates of 30 to 40 km per year have been observed in Australia (Carnegie *et al*., 2006). Other pathways of *S. noctilio* dispersal include movement of nursery stock, untreated pine logs and sawnwood, and untreated packing materials. The woodwasp is believed to have entered Argentina, Australia, New Zealand and South Africa in wooden packaging from Europe or North Africa (Keiran and Allen, 2004).

CONTROL MEASURES

The development of control strategies for *S. noctilio* originated in Australia and they are being used by various Southern Hemisphere countries where sirex has established. Control of this pest is achieved through a combination of silvicultural and biological measures including the restricted movement of infested materials, population monitoring through survey and trap trees, good silvicultural management practices, and the use of biological control agents (Carnegie, Eldridge and Waterson, 2005; USDA-APHIS, 2007). Since stressed trees are a prime target for sirex attack, silvicultural measures which maintain the health and vigour of trees and managing plantations optimally can significantly reduce the risk of sirex attack (Carnegie, Eldridge and Waterson, 2005).

A variety of biological control agents have been applied to target the sirex woodwasp. The most effective is the parasitic nematode, *Beddingia* (=*Deladenus*) *siricidicola*, which infects sirex larvae rendering adult female wasps sterile (Carnegie, Eldridge and Waterson, 2005; Haugen and Hoebeke, 2005). Infected females emerge and lay infertile eggs which are infected with nematodes in trees thereby assisting in the spread of the nematodes. Several parasitic wasps have also been introduced into Southern Hemisphere countries to help control sirex, including *Ibalia leucospoides*, *Megarhyssa nortoni*, *Rhyssa hoferi*, *R. persuasoria* and *Schlettererius cinctipes* (Carnegie, Eldridge and Waterson, 2005).

Thaumetopoea pityocampa

Other scientific names: *Bombyx pityocampa* Denis & Schiffermüller; *Cnethocampa pityocampa*; *Thaumetopoea wilkinsoni* Tams
Order and Family: Lepidoptera: Thaumetopoeidae
Common names: pine processionary caterpillar

Thaumetopoea pityocampa Denis & Schiffermüller, 1775 is considered the most destructive forest insect pest throughout the Mediterranean Basin. It is a tent-making caterpillar that feeds gregariously and defoliates various species of pine and cedar. Note the taxonomic status of this pest is under review. In Cyprus for example, *Thaumetopoea wilkinsoni* is the preferred scientific name though it is considered an eastern Mediterranean form (race) of *Thaumetopoea pityocampa.*


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Pine processionary caterpillars, Thaumetopoea pityocampa

DISTRIBUTION

Native: Africa (North), Europe (southern), Near East. This pest is found in almost all the countries around the Mediterranean Sea with the exception of Egypt and Libyan Arab Jamahiriya.
Introduced: No records to date

IDENTIFICATION

Eggs are laid in cylindrical egg masses that range in length from 4 to 5 cm and are covered in pale buff scales which conceal them and mimic the pine shoots (Dajoz, 2000).

The larvae develop through five instars, recognized by differences in head capsule size. First instar larvae have dull green bodies. After the second moult, the caterpillar assumes its definitive appearance and the paired reddish dorsal hair patches on each body segment are evident (EPPO/CABI, 1997). Typically, they are darker in colder areas varying from dull bluish-grey to black. Lateral hairs vary in colour from white to dark-yellow while dorsal hairs are yellow to dull orange. The average head width of the fifth instar caterpillar is 4.8 mm for males and 3.4 mm for females (EPPO/CABI, 1997). Mature larvae are about 40 mm in length with a black head capsule (EPPO/CABI, 1997).

Pupation takes place in oval, yellowish or white silken cocoons. Pupae are oval, approximately 20 mm in length, and pale brownish-yellow in colour that changes to dark reddish-brown (EPPO/CABI, 1997).

Adult female moths have a wing-span of 36 to 49 mm while males have a wing-span of 31 to 39 mm (EPPO/CABI, 1997). Both sexes have a hairy thorax, a stout abdomen and a tuft of large scales covering the last segments. Antennae are filiform in females and pectinate in males. Forewings are dull ashen-grey with darker veins, margins and three transverse bands. Hindwings are white, fringed with grey and have a characteristic dark spot in the anal region.

HOSTS

Pinus and *Cedrus* species are primary hosts; *Larix decidua* is occasionally attacked. The rate of survival of this insect pest varies depending upon which species of plant it feeds, i.e. it is higher for *Pinus sylvestris* and *P. nigra*.

BIOLOGY

The life cycle of the pine processionary caterpillar is typically annual but may extend over two years at high altitudes or in northern latitudes (EPPO/CABI, 1997). Daily average sunshine plays an important role in defining the northern limit of distribution. At northern latitudes and at higher altitudes, adults emerge earlier.

The day after emergence and mating, females oviposit on pines nearest to their pupation site although they can fly several kilometres in search of hosts thereby quickly increasing the extent of the outbreak (EPPO/CABI, 1997; Dajoz, 2000). Eggs are laid in masses containing 70 to 300 eggs typically near the tips of branches in the crown. The larvae hatch after 30 to 45 days and aggregate in colonies. There are five instars during which the larvae change location as host foliage is consumed (Dajoz, 2000). The larvae change colour at each moult and at the third instar urticating hair patches appear. They spin silken nests which are abandoned with each move until the fourth instar when the winter nest is built. The winter nest is a large silk bag up to 20 cm in length where the larvae spend the cold season (Dajoz, 2000).

Pupation processions occur at the end of the larval stage in late winter and early spring. A female is usually at the head of the procession which leads the colony in a file searching for a suitable site, typically a bright warm area near a host tree, to tunnel underground and pupate in the soil (EPPO/CABI, 1997; Dajoz, 2000). The processions occur at temperatures of 10 to 22 °C; at lower temperatures the colonies regroup and at higher temperatures they bury themselves wherever suitable soil conditions exist. The larvae burrow 5 to 20 cm below the ground where they weave a cocoon and pupate (Dajoz, 2000). The pupae enter diapause which breaks one month before adult emergence. The emergence period generally lasts less than one month for vigorous populations and approximately six weeks for weakened populations in regression (EPPO/CABI, 1997).

If environmental conditions are unfavourable, they can remain in the pupal stage for several years therefore resulting in moths from several generations emerging simultaneously when favourable conditions occur, causing severe outbreaks (Vega *et al.*, 1999).

SYMPTOMS AND DAMAGE

Infestation by *Thaumetopoea pityocampa* can be detected by the presence of white silken nests and brown and yellowing needles of partially eaten twigs (EPPO/CABI, 1997). The caterpillars feed on the foliage of host trees during the cooler months of the year causing significant defoliation. Defoliation damage is extremely serious in young reforested areas and young plantations where it may lead to death of trees. Although mature trees are rarely killed by this species, reduced growth rates are observed resulting in significant production losses. Host trees become stressed which can make

them more susceptible to other agents including attack by secondary pest species. This insect is regarded as a major pest of Mediterranean pine forests because it can contribute to increment losses of approximately 30 percent.

Thaumetopoea pityocampa larvae have urticating hairs that can cause skin irritation, conjunctivitis, respiratory congestions and asthma in humans. Contact with dead larvae, cocoons, nests and debris from infested pine forests can also cause dermatitis and other symptoms throughout the year. This significant problem not only affects recreational and residential areas but also impacts silvicultural operations and grazing in forests (EPPO/CABI, 1997).

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Damage caused by the pine processionary caterpillar to trees in Cyprus

DISPERSAL AND INTRODUCTION PATHWAYS

Adults are reasonably strong fliers and are thus capable of natural dispersal to new areas. Pupation processions may travel up to 37 m (EPPO/CABI, 1997). The movement of nursery stock and soil could transport *T. pityocampa* pupae.

CONTROL MEASURES

Control measures targeting the pine processionary caterpillar should be applied when the pest is at its most vulnerable and when its predators are not as active (Dajoz, 2000). The period between larval hatching and building of winter nests is the most effective. Chemical and biological control treatments are typically applied aerially and the most effective insecticide is *Bacillus thuringiensis.* For small outbreaks or when population density is low, mechanical control by cutting and burning winter nests is also recommended (EPPO/CABI, 1997). Pheromone traps are also used for detection, monitoring and mass trapping.

There are a number of predators, parasitoids and diseases which play a role in the biological control of *Thaumetopoea pityocampa*. Eggs are attacked by the wasp parasitoids *Anastatus bifasciatus*, *Baryscapus servadeii*, *Oencyrtus pityocampae*, *Tetrastichus servadei* and *Trichogramma* sp. and the orthopteran predators *Barbitiste fischeri* and *Ephippiger ephippiger* (EPPO/CABI, 1997; Schmidt, Mirchev and Tsankov, 1997). Pine processionary larvae are attacked by the dipteran parasitoids *Phryxe caudata*, *Compsilura concinnata* and *Ctenophora pavida*, the hymenopteran parasitoids *Erigorgus femorator* and *Meteorus versicolor*, and the dipteran predator

Xanthandrus comptus (EPPO/CABI, 1997; Dajoz, 2000). Birds are also known to feed on these caterpillars. Pupae are attacked by the dipteran parasitoids *Villa brunnea* and *V. quinquefasciata*, the wasp parasitoids *Coelichneumon rudis*, *Ichneumon rudis* and *Conomorium eremita*, and the fungus *Beauveria bassiana* (EPPO/CABI, 1997; Dajoz, 2000). The most important diseases of *T. pityocampa* are caused by the viruses *Borrelina* sp. and *Smithiavirus pityocampae*, the bacteria *Bacillus thuringiensis* and *Clostridium* sp., and the fungi *Aspergillus flavus*, *Beauveria bassiana*, *Cordyceps* sp., *Metarhizium anisopliae*, *Paecilomyces farinosus*, *P. fumoso-roseus* and *Scopulariopsis* sp. (EPPO/CABI, 1997).

To avoid the accidental introduction of this pest into new areas, nursery stock, plants and trees, particularly *Pinus* and *Cedrus* species, should be examined for the presence of egg masses, caterpillar colonies and pupae (EPPO/CABI, 1997).

Thaumetopoea processionea

Other scientific names: *Bombyx pityocampa* Denis & Schiffermüller; *Cnethocampa pityocampa*; *Thaumetopoea wilkinsonii* Tams
Order and Family: Lepidoptera: Thaumetopoeidae
Common names: oak processionary moth

Thaumetopoea processionea Linnaeus, 1758 is a major defoliating pest of oak in Europe. Native to central and southern Europe, its range has been expanding northwards where it is causing significant problems in other European countries.

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Oak processionary caterpillars, Thaumetopoea processionea

DISTRIBUTION

Native: Europe (central and southern)
Introduced: Europe (northern): Its distribution is expanding northwards and it is now firmly established in Belgium, northern France and the Netherlands, and has been reported from southern Sweden and the United Kingdom.

IDENTIFICATION

Adults have a wingspan of 30 to 32 mm and grey forewings with white and some darker grey markings (UK Forestry Commission, n.d.).

Newly hatched larvae have a uniformly brown body and dark head which lightens as they grow to become greyer in colour (UK Forestry Commission, n.d.). These mature larvae have a single dark stripe on the middle of the back and a whitish stripe along each side. The length of the body is covered by thousands of short hairs and reddish-orange warts with clumps of very long white hairs.

HOSTS

Oak trees (*Quercus* spp.) are the main hosts, but other broadleaved trees such as hornbeam (*Carpinus* spp.), hazel (*Corylus* spp.), beech (*Fagus* spp.), sweet chestnut (*Castanea* spp.) and birch (*Betula* spp.) have also been attacked by this pest, mainly when they are grown next to severely defoliated oaks.

BIOLOGY

Thaumetopoea processionea has one generation per year (Dajoz, 2000). Females lay their eggs, between 100 to 200, from July to early September on twigs and small branches in the canopy (UK Forestry Commission, n.d.). They are deposited in groups forming plaques of a single layer of eggs which are covered with greyish scales and remain on the branches over the winter.

Larvae can be found from April to June. They feed in groups and congregate in communal white silk nests under branches or on the trunk when not feeding. Larval nests are typically small, about the size of a tennis ball, but much larger ones have been reported. The larvae pass through 6 to 10 instars, shedding their skin inside the nests between each stage as they grow (UK Forestry Commission, n.d.; Dajoz, 2000). The cast skins and hairs accumulate in the nests leading them to take on an orange-brown colour over time. The larvae typically migrate in procession; following one another head-to-tail in long lines to and from the nest and from one feeding position to another, which gives rise to the common name.

Pupation takes place in the nest typically during late June or early July (UK Forestry Commission, n.d.). Adults typically emerge in August. They are nocturnal and live for only a day or two (Dajoz, 2000).

SYMPTOMS AND DAMAGE

Larvae feed on the leaves of host trees causing significant defoliation. Trees are not usually killed but repeated attacks can severely reduce health and vigour.

Thaumetopoea processionea larvae have urticating hairs that can cause skin irritation, conjunctivitis, respiratory congestions and asthma in humans. Contact with dead larvae, cocoons, nests and debris from infested oak forests can also cause dermatitis and other symptoms throughout the year. These hairs are also carried on air currents and therefore direct contact is not necessary to cause health problems. The oak processionary moth tends to be more abundant on urban trees and along forest edges where there is a high probability of it coming into contact with people.

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Oak branch defoliated by Thaumetopoea processionea

DISPERSAL AND INTRODUCTION PATHWAYS

Adult males are strong fliers and are thus capable of natural dispersal to new areas. Larval processions are also known to travel some distance to find suitable hosts.

Important possible pathways of introduction include the movement of nursery stock, live oak trees, branches and roundwood (with bark) which is infested with the eggs or even larvae.

CONTROL MEASURES

If detected, egg masses can be destroyed before they hatch the following spring. The application of biological pesticides against the larval stages soon after they hatch in the spring can be effective. Destruction of the nests during the brief pupal stage in the summer can reduce the number of adult moths that will emerge. Debarking of roundwood can help prevent the spread of this pest to new areas.

A number of species are known enemies of the oak processionary moth (Dajoz, 2000). Non-specific predators include the beetles *Xylodrepa quadripunctata*, *Calasoma sycophanta* and *C. inquisitor*, the heteropterans *Picromerus bidens* and *Troilus luridus*, and the dipteran predator *Xanthandrus comptus*. Non-specific parasitoids include species of flies such as *Ctenophorocera pavida*, *Zenilia libatrix*, *Phorocera agilis* and *Compsilura concinnata*, and the wasps, *Pimpla examinator*, *Theronia atalantae* and *Trichogramma*, *Anastatus* and *Phobocampe* species. The dipteran *Carcelia processioneae* is a host specific parasite. Other predators include some species of birds and small mammals.