Dendrolimus pini

Scientific Name
Dendrolimus pini Linnaeus 1758

Synonyms:
Bombyx pini Linnaeus
Dendrolimus segregatus Butler
Gastropacha pini Linnaeus
Lasiocampa pini Linnaeus
Phalaena pini Linnaeus

Common Name
Pine tree lappet, pine lappet, pine moth

Type of Pest
Moth, defoliator

Taxonomic Position
Class: Insecta, **Order:** Lepidoptera, **Family:** Lasiocampidae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List (2006 – 2013)

Figure 1. Adult male *Dendrolimus pini* (Image courtesy of Stanislaw Kinelski, bugwood.org).

Pest Description
Eggs: "Eggs are about 2 mm [approx. $^{13}/_{16}$ in] long, blue green in color when first deposited, later turning to gray" (Ciesla, 2004).

Larvae: "Mature larvae range in size from 50-80 mm [approx. 2 to 3 $^{1}/_{8}$ in] and are covered with soft gray or brownish hairs. Thoracic segments 2 and 3 have thick bands of hairs of alternating steel blue and black. The dorsal surface of each abdominal segment contains a black mark flanked by irregular white lines" (Ciesla, 2004).

"A V-shaped spot [occurs] on the eight segment of the body" (Kolk and Starzyk, 1996).

Pupae: "Pupae range from 30-35 mm [approx. 1 $^{3}/_{16}$ to 1 $^{3}/_{8}$ in] in length, are brown to black in color with both ends rounded. They are enclosed in a yellow-brown spindle shaped cocoon, which also contains remnants of the steel blue thoracic hairs" (Ciesla, 2004).

Adults: "Male reddish ochre, more or less gray: superior wings chestnut at the base and extending to the disc; before the middle is a sinuated striga with a lunular white spot

upon it, and beyond the middle an oblique ochraceous fascia, the inner margin crenated with a brown line, the outer one very much sinuated and marked with strong brown spots: inferior wings pale castaneous. Female paler" (Watson and Dallwitz, 2007).

"The first pair of wings are with a small white spot and wide dark strip. Antennae of females are slightly saw-shaped, while those of males are double comb-shaped" (Kolk and Starzyk, 1996).

"Adults are covered with thick scales on both the wings and body. Males have a wingspan of 50-70 mm [approx. 2 to 2 ¾ in] and females a wingspan of 70-90 mm. The forewings are gray-brown to brown in color. They contain a reddish brown lateral band, edged on both sides with an irregular dark-brown to black stripe. The hind wings are red brown to gray brown in color. Body color is brown. Coloring of the males is typically darker than the females" (Ciesla, 2004).

The sex of moths may be determined at eclosion (emergence from pupal cocoons) "from the form of the antennae which are more plume-like in males" (Winokur, 1991).

Figure 2. Larva of *Dendrolimus pini* (Image courtesy of William Ciesla, Forest Health Management International, bugwood.org).

Descriptions of the life stages and images can be found in USDA (2012).

Biology and Ecology

Dendrolimus pini typically has one generation per year. However, under adverse conditions (population density, climatic conditions, temperature, host availability and quality, presence of natural enemies, etc.), two years may be required to complete development. *D. pini* overwinters in the larval or pupal stages (reviewed in Malyshev, 1987; Kolk and Starzyk, 1996). Outbreaks are cyclical (Malyshev, 1987). The density of *D. pini* between outbreaks remains higher in areas considered outside the outbreak center (Malyshev, 1987). A maximum of 420 to 475 larvae per tree have been observed during an outbreak in Novokhoperskiye plantation (Voronezh Province, Russia; formerly European USSR) (Malyshev, 1987).

The biology of *D. pini* is similar to that of *D. superans*, and is reviewed in Geispits (1965), Malyshev (1987), Kolk (1996), Pszczolkowski and Smagghe (1999), Winokur (1991) and Ciesla (2004).

In its native range, *D. pini* adults emerge in midsummer and live for about ten days. Flight typically occurs at night between late June and August. Mating occurs over several hours at night. Females fly after oviposition begins; however, they remain flightless on the lower part of the host tree until egg deposition is partially completed. Females deposit 150 to 300 eggs in groups of 20 to 100 on needles, branches, and bark crevices.

The egg incubation period is 14 to 25 days. Egg mortality is significant at or above 32°C (89.6°F). Larvae hatch between late summer and early fall and disperse by crawling or ballooning on strands of silk carried by air currents. Caterpillars are most active at dusk and dawn. When feeding, larvae consume all or part of a needle. Larvae feed immediately after egg hatch, initially on old growth in spring until new needles emerge, and then on new growth until late fall. Larvae complete 2 to 3 molts before overwintering in forest litter. Larvae move from the host to the forest floor in autumn once day length is under 12 hours. The majority of larvae overwinter in forest litter within 1 m (3 ¼ ft) of a host tree. Under natural conditions, diapause is induced when the temperature falls below 5°C (41°F). Larvae typically enter diapause as mid- to late-instars and break diapause when forest litter temperature reaches 3°C (37.4°F). Exposure to daylengths <9 hours for a period of 20 to 35 days can induce diapause in all instars. Diapause is inhibited by daylengths over 15 to 17 hours. Larvae may also enter summer diapause when conditions become unfavorable for development. Early in spring, overwintered larvae return to tree crowns and resume feeding. The larvae preferentially feed on year-old needle growth but may also feed on the tender bark of young tree shoots. Larvae feed intensely following diapause, consuming the majority of food necessary for completing development (3 to 5 times the amount of foliage consumed the previous fall). Feeding continues through midsummer followed by pupation.

Pupation occurs between late June and August. The pupae form spindle-shaped cocoons spun loosely with silk, needles, and small branches in bark crevices, tree crowns, or nearby vegetation. This stage typically requires 18 to 35 days under favorable conditions.

A review of the biology and ecology can be found in USDA (2012).

Damage

D. pini causes defoliation of conifers on both new and old growth. Severe or repeated defoliation over several years can result in tree death. During an outbreak, caterpillars are conspicuous, and defoliation can be widespread (reviewed in Ciesla, 2004).

Pest Importance

Dendrolimus pini is an economically important defoliator of pine and coniferous forests in Europe and Asia (Leśniak, 1976a; 1976b; 1976c; Malyshev, 1987; Pszczolkowski and Smagghe, 1999; reviewed in Ciesla, 2004). Overwintered larvae cause more damage because they consume three to five times greater the volume of needles consumed in the fall (reviewed in Ciesla, 2004).

Like *D. superans*, densities of *D. pini* typically build over several years, reach an outbreak condition, and then collapse (Varley, 1949; Malyshev, 1987). Outbreaks have been reported in pine forests and vary in size and extent depending on many factors including population density, dispersal behavior, forest type, host availability and quality; stand age; higher temperatures and lower precipitation; and soil type (e.g., outwash plains and sandy soils) (Leśniak, 1976a; 1976b; 1976c; reviewed in Ciesla, 2004). Cyclic outbreaks have also been observed to coincide with solar activity, though the relationship between solar radiation intensity and outbreak frequency is not well understood (Leśniak, 1976c).

Outbreaks of *D. pini* are familiar in Europe and can last 7 to 8 years. Outbreaks have been reported in Poland since the late 18th Century. In Poland, chemical control was used between 1946 and 1995 to reduce damage to 233,000 ha (575,755 acres) of forests caused by *D. pini*. In northern Germany, historic outbreaks in the 13th and 19th centuries damaged more than 170,000 ha (420,079 acres) of forest. An outbreak in northeastern Germany in the mid 1990s caused heavy defoliation to 83,700 ha (206,827 acres). Repeated annual defoliation can result in tree mortality. Weakened, stressed trees are subject to attack by secondary pests, and areas with extensive tree mortality are vulnerable to forest fires (reviewed in Ciesla, 2004).

Establishment of *D. pini* in the United States could have adverse impacts on domestic and international trade and would likely result in domestic and/or international quarantines or requirements for additional treatment of potentially infested host materials (reviewed in Ciesla, 2004).

Outbreaks in Europe have stimulated the use of aerial applications of synthetic pyrethroids or naturally-derived insecticidal compounds for insect suppression. The non-target impacts of these practices have not been evaluated (reviewed in Ciesla, 2004; EPPO, 2005).

Dendrolimus pini has a moderate host range, feeding primarily on needles of coniferous hosts. However, 82% of forests in the western United States are coniferous, so the potential impact on forests is significant (reviewed in Ciesla, 2004).

Though rare and not well understood, *D. pini* can potentially impact human health. Dendrolimiasis is an allergic or hypersensitivity reaction (inflammation) affecting skin and/or joints (Diaz, 2005).

Known Hosts

Dendrolimus pini feeds on multiple species of *Pinus* (Lindelöw and Björkman, 2001). Winokur (1991) lists *Pinus sylvestris* as the preferred host for *D. pini*. This insect prefers to feed on 20 to 80 year-old pine stands (Sukovata et al., 2002).

Main host

Pinus sylvestris (Scots pine) (Ciesla, 2004).

Other hosts

Abies spp. (fir), *Abies alba* (silver fir), *Abies grandis* (grand fir), *Cedrus deodara* (Himalayan cedar), *Juniperus communis* (common juniper), *Larix sibirica* (Siberian larch), *Picea* spp. (spruce), *Picea abies* (Norway spruce), *Picea sitchensis* (Sitka spruce), *Pinus* spp. (pine), *Pinus contorta* (lodgepole pine), *Pinus cembra* (Swiss stone pine), *Pinus halepensis* (allepo pine), *Pinus mugo* (mountain pine), *Pinus nigra* (black pine), *Pinus pinaster* (maritime pine), *Pinus pinea* (Italian stone pine), *Pinus sibirica* (Siberian stone pine), *Pinus strobus* (eastern white pine), *Pinus thunbergii* (Japanese black pine), *Pseudotsuga menziesii* (Douglass-fir), and *Tsuga canadensis* (eastern hemlock) (Priesner et al., 1984; Winokur, 1991; Kolk and Starzyk, 1996; Pszczolkowski and Smagghe, 1999; Johansson et al., 2002; Sukovata et al., 2002; Ciesla, 2004; CAB, 2005; Diaz, 2005; reviewed in USDA, 2012).

Pathogen or Associated Organisms Vectored

Dendrolimus pini is not known to vector any pathogens or other associated organisms.

Known Distribution

Dendrolimus pini is native to central Asia and North Africa and is usually found at elevations >200 m (~660 ft) above sea level (Diaz 2005).

Africa: Morocco; **Asia:** China, Kazakhstan, Republic of Georgia, and Turkey; **Europe:** Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France (including Corsica), Germany, Greece, Hungary, Italy (including Sicily), Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain (including Balearic Islands), Sweden, Switzerland, Ukraine, and United Kingdom[1]; **Oceania:** Aegean Islands (Spain) (Gäbler, 1949; Varley, 1949; Geispits, 1965; Leśniak, 1976a; 1976b, 1976c; Malyshev, 1987; Winokur, 1991; Kovalev et al., 1993; Kolk and Starzyk, 1996; Johansson et al., 2002; Sukovata et al., 2002; CAB, 2005; Diaz, 2005; Zolotuhin and van Nieukerken, 2011; reviewed in USDA, 2012).

[1]This species has been considered a migrant species in the United Kingdom. However a breeding population has recently been confirmed in Scotland (Forest Research, 2009).

Pathway

There have been no recorded interceptions of this pest at ports of entry (AQAS, 2011, queried December 6, 2011). Although there is not a demonstrated capacity for dispersal through human assistance, the eggs and larvae hidden in bark crevasses may be moved through international trade of unprocessed pine logs (Ciesla, 2004).

Natural spread can occur through air currents (ballooning by first instar larvae) and crawling (mature larvae). Adults can move through flight, but females will not fly until some of their eggs have been laid (Ciesla, 2004).

Potential Distribution within the United States

The known distribution of *D. pini* suggests that the insect may be most closely associated with two biomes, both of which occur in the United States: (1) temperate coniferous forests; and (2) temperate broadleaf and mixed forests. Both biomes account for approximately 47% of the area and are generally found east of the Mississippi River, and scattered throughout the Intermountain West, the Pacific Northwest, and the Sierra-Nevada Mountains.

Survey

CAPS-Approved Method*:

The CAPS-approved method is a trap and lure combination. The trap is a milk carton trap. The lure is effective for 28 days (4 weeks). This trap and lure combination may also be used to report negative data for the CAPS target *Dendrolimus sibiricus*.

IPHIS Survey Supply Ordering System Product Names:

1) *Dendrolimus pini – Dendrolimus sibiricus* Lure
2) Milk Carton Trap

The lure is hung inside the top of the trap at the level of the entry ports. Preferably, the lure is placed inside the lure holders, which are typically distributed with the lures, and the lure holder is stapled to the trap. If the lure holder is not available, the lure can be stapled to a garden tie and hung inside the trap. The killing agent, the DDVP strip, is placed in the bottom of the trap.

The funnels (Figure 3) that are used in the modified milk carton trap (see trap modification instructions below) are no longer available. If you have funnels leftover from previous seasons, please continue to use them. If you do not have the funnels, continue to use the modified milk carton traps.

Trap modification instructions:

Modify the standard gypsy moth milk carton by cutting a single large entry port (2.5 cm wide x 3 cm (1 x 1 $^{3}/_{16}$ inch) high) in each side by using a utility knife or similar tool to cut out the section of

Figure 3. Internal funnel for *Dendrolimus* traps. (Image courtesy of David Lance, USDA-APHIS-PPQ.)

paperboard between the two existing entry ports. A plastic funnel (Figure 3) is placed inside the trap (tube-down) so that the top edge of the funnel is at the level of the bottom of the entry ports.

The funnels can be reused for multiple years if cared for properly. Funnels should be removed from traps at the end of the season, washed in soap and water, rinsed, and stored dry. Please keep the funnels and re-use in subsequent years or ship the funnels back to the Otis lab so that other states may use them.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Survey site and selection:
Traps should be hung in trees that are presumed to be potential hosts. In Asia, multiple species of larch, fir, spruce, and pine are attacked (Lance, 2006).

Time of year to survey:
"The available literature indicates that adult [*D. sibiricus*] and *D. pini* may be present from June to August in their native ranges (presumably on the earlier side in more southern areas), so detection trapping should focus on that period" (Lance, 2006).

Literature-Based Methods:
Baited traps: Traps baited with sex pheromones are the most effective method for monitoring adults. Priesner et al. (1984) found tetratraps baited with 1000 µg of the sex pheromone (Z,E)-5,7-dodecadienal had the highest total catch of adult male *D. pini*. Kovalev et al. (1993) improved capture of males with a 60:40 mixture of (Z,E)-5,7-dodecadienal:(Z,E)-5,7-dodecadien-1-ol over (Z,E)-5,7-dodecadienal alone. The two compounds are also the major components of the sex pheromone of the closely related *D. superans*, which is native to Asian Russia and the Far East. Klun et al. (2000) and Khrimian et al. (2002) used a 1:1 mixture of these two dienes to attract *D. superans*. The sex pheromone of *D. punctatus*, (Z,E)-5,7-dodecadien-1-yl acetate, is a "powerful inhibitor of the sex pheromone of *D. pini*" (Kong et al., 2001). (E,Z)-5,7-dodecadienal is also inhibitory (Priesner et al., 1984).

Not Recommended: Monitoring of populations of *D. pini* can be achieved through several methods. Soil sampling is useful for collecting overwintering larvae of *D. pini*, but Johansson et al. (2002) note this method "may be unreliable at low population densities." Overwintering larvae are generally found in litter and mineral soil within ~1m of the tree (Kolk and Starzyk, 1996; reviewed in Ciesla, 2004).

Not Recommended: A technique developed for sampling of *D. superans* in Eastern Siberia may also be useful for sampling *D. pini*. The area around a tree is cleared of understory vegetation, a tarp is placed around the base, and the tree is struck six to eight times with a "kolot", a large, 2 to 3.5 m (6 ½ to 11 ½ ft) log. The larvae are dislodged from the tree and fall onto the tarp, where they are counted and identified.

This method is not recommended for healthy trees as it is highly destructive to the tree being sampled (Vartanov, 2002).

Key Diagnostics/Identification

CAPS-Approved Method*:

Confirmation of *D. pini* is by morphological identification. This species may occur in mixed populations with similar-looking species. Identification should be confirmed by a qualified taxonomist. For larvae, use Passoa (2007); for adults, use Passoa (2009).

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

Easily Confused Pests

Dendrolimus pini may be confused with the closely-related *D. superans* (EPPO, 2005). Neither species is present in the United States (reviewed in Ciesla, 2004). *Dendrolimus pini* may also be confused with other lasiocampids, including multiple species in the genus *Gloveria*, which occur in the U.S.

Dendrolimus pini may be differentiated from *Gloveria* by dissecting the male genitalia (Passoa, 2009). The valve of *Dendrolimus pini* and *D. sibiricus* have two projections, the smaller one either $^{1}/_{5}$ or $^{3}/_{4}$ as long as the larger one (Passoa, 2009). The valve of *Gloveria* have a single projection (Passoa, 2009).

Commonly Encountered Non-targets

The trap and lure for this species may also catch a significant number of the following non-target native insects: *Malacosoma disstria* (forest tent caterpillar), *Malacosoma californicum* (western tent caterpillar, lower probability), and *Malacosoma americanum* (eastern tent caterpillar, low probability) (Lance, 2006).

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