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Pandora Moth

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Pandora moth, *Coloradia pandora* Blake (Lepidoptera: Saturniidae) is a native defoliator of pine forests in the western United States. This insect can be found throughout most of the West. Three subspecies are recognized: *C. pandora pandora* Blake, *C. pandora davisi* Barnes & Benjamin and *C. pandora linseyi* Barnes & Benjamin. The former two subspecies occur in the interior west and the latter is found in California and Oregon.



Outbreaks have occurred in Arizona, California, Colorado, Utah, Oregon and Wyoming (Figure 1). The first recorded outbreak took place in central Oregon during the 1890s on the Klamath Indian Reservation. Other outbreaks have occurred in central Oregon from 1918-1925, 1963-1968 and 1988-1996. These outbreaks developed in areas of loose, granular soils of volcanic origin, where larvae can easily burrow into the soil to pupate. Tree ring analysis of old growth ponderosa

pine forests in central Oregon suggest that 22 pandora moth outbreaks have occurred over the past 622 years. Intervals between outbreaks were highly variable, ranging from nine to 156 years. An outbreak occurred in lodgepole pine forests on the western slopes of the Continental Divide in Colorado from 1937 to 1939. During 1959 to 1966, outbreaks occurred in portions of California, Colorado, Utah and Wyoming. Another outbreak occurred from 1978-1984 on the north Kaibab Plateau in northern Arizona,

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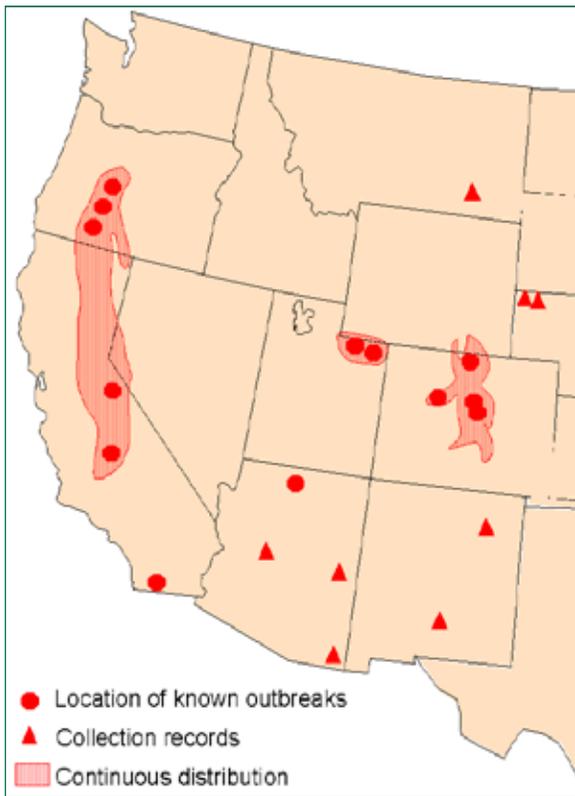


Figure 1 – Approximate distribution of pandora moth in the western United States and location of known outbreaks.

in an area with soils of a limestone base. These outbreaks have caused extensive defoliation, growth loss and some tree mortality, usually associated with secondary bark beetle attacks when pandora moth outbreaks coincided with drought.

Host Trees

Larvae feed on the foliage of several species of pines. Principle hosts are Jeffrey pine, *P. jeffreyi*; lodgepole pine, *P. contorta* and ponderosa pine, *P. ponderosa*. Coulter pine, *P. coulteri*; pinyon pine, *P. edulis* and sugar pine, *P. lambertiana* are occasional hosts. In Oregon outbreaks have occurred on both ponderosa and lodgepole pines. The Colorado outbreak occurred on lodgepole pine.

Outbreaks in Arizona have occurred on ponderosa pine and outbreaks in California on Jeffrey pine. Outbreaks typically occur in mature stands although light defoliation has also been reported in understory trees of 20 feet or less in height.

Evidence of Infestation

Defoliation, which can result in complete stripping of the needles, is the most conspicuous indicator of infestations (Figure 2). In a given area, heavy defoliation occurs every other year because pandora moth requires two years to complete a generation with the second year spent in the soil in the pupal stage.

Heavily defoliated pine forests are devoid of foliage and have a gray cast when seen from the air or from a distance. As trees recover, crowns are thin and have only the current year's foliage.

Mature larvae are large and conspicuous, as are their cast skins and stubs of damaged foliage. Another indicator of infestation is the presence of large amounts of larval droppings, or frass, on the forest floor. Larvae migrate from branches to the forest floor to pupate.

Moths are attracted to lights and can sometimes be found long distances from forested areas. Presence of large numbers of both living and dead moths, especially around street and parking area lights is an indicator

that an outbreak may be either imminent or underway in nearby pine forests.

Life Stages

Pandora moth adults are one of the largest American forest insects. They are heavy bodied moths, gray-brown in color with a wingspan of 70-110 mm (2.75-4.3 inches). They have a small dark spot near the center of each wing. The base and anterior margins of the hind wings are clothed with pink hairs, which may be slightly darker on males (Figure 3).

Eggs are spherical, pale blue-green when first deposited and later turn pale blue-gray to white and are about 3 mm long (Figure 4).

Larvae are about 5 mm (less than ¼ inch) long when first hatched. They



Figure 3 – Adult female pandora moth at rest on pine branch



Figure 2 – Heavy defoliation of ponderosa pine by pandora moth in central Oregon

have shiny black heads and brown to black bodies covered with short black hairs (Figure 5) When mature, larvae are 5.7 to 7.6 cm (2 ¼ - 3 inches) long, vary in body color from brown or black to dark green with white lines or bands along the sides of each body segment. The ends of each body segment are light red-brown. Head capsules are dark red-brown. Color pattern of mature larvae resembles that of a pine branch (Figure 6).

Pupae are dark red or purple-brown, from 25-35 mm (1–1.4 inches) long and not enclosed in a cocoon (Figure 7).

Life History and Habits

Two years are required to complete a generation. Therefore, during outbreaks, defoliation occurs every other year. Populations in one location are not necessarily synchronous with populations in another location. For example, recent outbreaks in northern Arizona caused defoliation in odd years, while in central Oregon, defoliation occurred during even years. In addition, within an outbreak, some individuals may be out of synchronization with the rest of the population and a few



Figure 4 – Pandora moth egg cluster on pine needles

adults may be present during the year when most of the population is in the larval stage.

Adults are active during late July and early August. During outbreaks, thousands of moths can be seen on branches or at rest on the sides of buildings, posts, poles and lights. After mating, females deposit eggs either singly or in clusters of 2-38 on needles of host pines or on the sides of fence posts or buildings. When competition exists among female moths, eggs are also deposited on bark, understory vegetation, and litter. A single female can deposit an average of 145 eggs.

Average life span of an adult is about one week.

Eggs hatch in September and larvae begin to feed in small colonies on the current year's foliage. Larvae go through five growth stages or instars. They overwinter as second or third instar larvae at the base of needles and may feed on warm,

sunny days. Active feeding resumes the following spring and it is during this period that heaviest defoliation occurs. Feeding is usually completed by late June and larvae crawl down the trees and enter the soil, where they construct elliptical cells and pupate. The second winter is passed as pupae and moths emerge the following

summer. A small portion of pupae may enter an extended diapause and have a three-year life cycle.

Economic Importance

The pandora moth's two-year life cycle, with heavy defoliation every other year during outbreaks, allows for some tree recovery. However, growth loss and some tree mortality have been associated with outbreaks. For example, during an outbreak on the North Kaibab Plateau of northern Arizona, defoliation reduced growth by 10-15% on trees 14 inches dbh and larger, but tree mortality was



Figure 5 – Colony of young pandora moth larvae

less than 1 percent. Prior to outbreaks, host pines may have a three to five year needle complement. Heavy defoliation may result in the loss of all but the current year's growth. Therefore, tree growth may be reduced for two to four years after the outbreak. Resumption of full growth may occur sooner if longer needles are produced in the growing seasons immediately following the outbreak. Defoliation is unsightly and large numbers of larvae and moths in or near forested communities or in developed recreation areas are considered a nuisance.

Mature larvae are a traditional food for the people of the Paiute Tribe of the Owens Valley/Mono Lake areas of California. Every other year, during the second or third week of June, they search for evidence of larvae around the bases of large Jeffery pines. Trees with larvae are located by the presence of frass on the forest floor. The people return to these trees in early July to collect mature larvae as they migrate from the tree crowns to pupation sites in the soil. Collection and preparation of pandora moth larvae is a traditional family activity that can last for two to three weeks. Mature larvae are collected in trenches dug around the drip line of large infested pines. The Klamath and Modoc tribes collect and roast the pupae, which are also considered a delicacy.



Figure 6 – Mature larva of pandora moth

Related Species

Several species related to pandora moth also occur in the western United States. The Black Hills pandora moth, *Coloradia doris* Barnes, occurs in Colorado, Wyoming, Montana, and South Dakota. An outbreak of this species occurred between 1938 and 1939 in ponderosa pine forests in the Black Hills of South Dakota and Wyoming. Larvae are longer and have more conspicuously branched spines than those of pandora moth. Adults resemble pandora moth except the hind-wings are more translucent. Eyespots on the forewings are not as prominent and are oblong instead of round.

Coloradia velda Johnson & Walter is closely related to *C. doris* and was recognized as a separate species in 1980. It is endemic to the San Bernadino Mountains of California where larvae feed on foliage of singleleaf pinyon, *P. monophylla*. This species has one generation per year. Adults are active in spring and early summer. Eggs hatch in July and larvae feed gregariously until they reach the fourth and fifth instars. Larvae drop to the soil in September,



Figure 7 – Pandora moth pupae in soil

pupate at a depth of 10-15 cm and overwinter.

Coloradia luski Barnes & Benjamin is the smallest species of *Coloradia* found in the United States and closely resembles *C. doris*. This species is found in Arizona and New Mexico and larvae feed on pine foliage.

Natural Controls

Several natural enemies either keep populations at low levels or contribute to the collapse of outbreaks. One of the more important is a wilt disease, probably caused by a polyhedrosis virus, which infects full grown larvae. Infected larvae shrivel, turn dark and die. This disease was a key factor in the collapse of outbreaks in Colorado. A disease that infects pupae has also been reported.

The golden mantled ground squirrel, *Callospermophilus lateralis*, feeds on pupae and is an important natural control factor in California and Oregon, where pupae are available as food for about three months in late summer and fall. In the Rocky Mountains, pupae are available for shorter periods because of an earlier onset of cold temperatures.

Several birds are predators of pandora moth. Creepers and nuthatches feed on egg clusters and vireos and Clark's nutcrackers feed on larvae. Other birds may be repelled by the spines on larvae. Robins, roadrunners and other birds have been seen feeding on moths.

Three species of parasitic wasps attack eggs and at least six species of insects are known to parasitize larvae. High soil temperatures can kill larvae when they enter the soil to pupate. During outbreaks, moths are attracted to city lights and locations where there may be fewer opportunities to deposit eggs.

Management

Periodic thinning of pine stands, to maintain desirable stocking levels and reduce incidence of dwarf mistletoe, *Arceuthobium* spp., should also minimize growth loss and tree mortality in areas subject to outbreaks. Prescribed fire can kill up to 70% of the pupae, but mortality rates are variable because in some sites fuel levels are too low to carry a fire of sufficient intensity. Moths apparently are attracted to flames from prescribed fires and killed, which can cause from 2-17% mortality of local populations. Prescribed burning does not consistently cause high levels of mortality to pandora moth life stages and should be used only when burning achieves other objectives, such as fuels management.

Several chemicals and the biological insecticide, *Bacillus thuringiensis*, applied either from the ground or air

are effective direct control agents. However, these should not be used in areas where indigenous tribes are collecting larvae for food.

Additional Information

Private landowners get more information, including currently registered and effective insecticides from County Extension Agents, State Forestry Departments, or State Agriculture Departments. Federal resource managers should contact USDA, Forest Service, Forest Health Protection (www.fs.fed.us/foresthealth/). This publication and other Forest Insect and Disease Leaflets can be found at www.fs.fed.us/r6/nr/fid/wo-fidls/.

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