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The Pandora Moth

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The pandora, moth, *Coloradia pandora* Blake, periodically causes severe damage to pine forests in the Western United States. The insect is chiefly found in inland mountain areas from Montana, to southern New Mexico and Arizona on the east, and from Oregon to southern California on the west (fig. 1). Outbreaks are limited to pine areas having loose soils.

The earliest recorded outbreak was on the Klamath Indian Reservation, Oreg., shortly before 1893. Earlier unrecorded outbreaks were indicated by the familiarity of Indian tribes in California and Oregon with this insect as a source of food. In parts of the western region, outbreaks have occurred at about 20-to 30-year intervals and have lasted as long as 6 to 8 years.

The pandora, moth caused extensive damage to ponderosa pine *(Pinus ponderosa* Laws.) stands in south-central Oregon from 1918 to 1925, and to lodgepole pine (*Pinus contorta* Dougl.) in north-central Colorado from 1937 to 1940. In both outbreaks, trees died as a direct result of defoliation. But in the Oregon outbreak, tree mortality from subsequent attacks by bark beetles *(Dendroctonus brevicomis* Lec. and *D. monticolae* Hopk**.)** in defoliated stands caused a greater immediate loss than direct damage by the pandora, moth and was estimated at 100 million board feet. Surviving trees showed reduced vigor and temporary loss in radial growth.

In 1959-66, outbreaks occurred in Oregon, California, Colorado, Wyoming, and Utah. The Rocky Mountain outbreaks in Colorado, Wyoming, and Utah were of longest duration. Epidemics of bark beetles built up in the Utah pandora moth areas during 1960 and 1961. But these were thought to be extensions of an adjacent, very serious bark beetle epidemic, active since 1957. The concurrent Colorado and Wyoming infestations were not followed by bark beetle outbreaks, nor were those in Oregon and California.

Outbreaks have occurred only in areas where soils are loose enough to permit caterpillars to bury themselves prior to pupation. Outbreaks are chiefly on pumice soils in the Pacific Coast States and on decomposed granite soils in the Rocky Mountains.

Host Trees

Principal hosts of the pandora moth are ponderosa, Jeffrey *(Pinus jeffreyi* Grev. & Balf.), and lodgepole pines; Coulter pine (*P. coulteri* D. Don) and sugar pine (*P. lambertiana* Dougl.) are sometimes attacked. Outbreaks have developed on ponderosa, and lodgepole pines in Oregon, lodgepole pine in the Rocky Moun-

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-tain States, and ponderosa and Jeffrey pines in California, mostly in mature-stands. Light infestations in a mature stand are sometimes restricted to understory trees of 20 feet or less.

Description

The pandora moth is one of the largest forest insects in North America. Moths (fig. 2, *A* and *B*) are 1 to 1½ inches long and have a wingspread of 3 to 4½ inches. Forewings are brownish gray and hindwings light pinkish gray, each marked with a black dot and a dark wavy line. Eggs are globular, about one-tenth of an inch long, at first bluish green and later bluish gray, and are

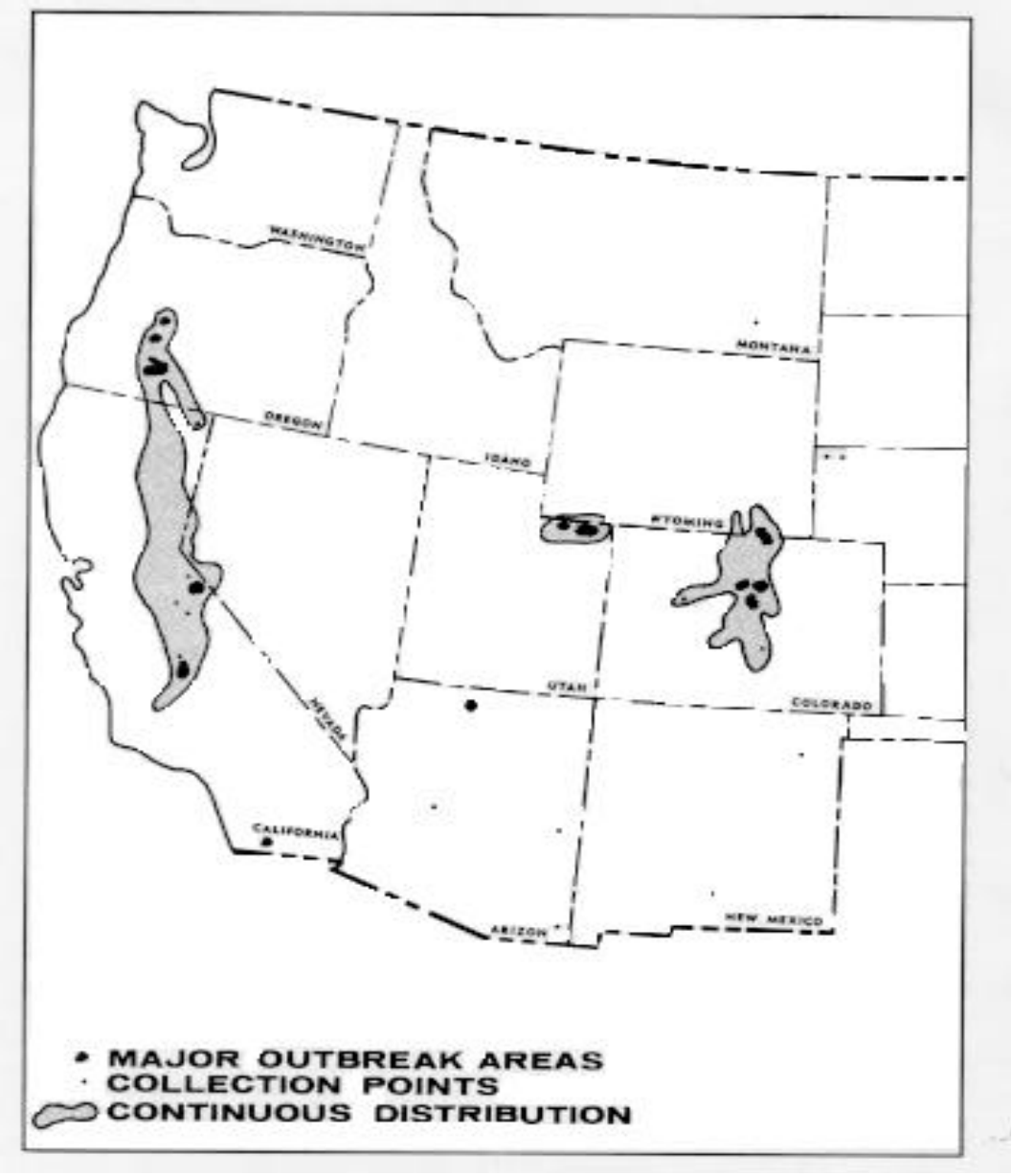

Figure 1.—Distribution of pandora moth in the Western United States.

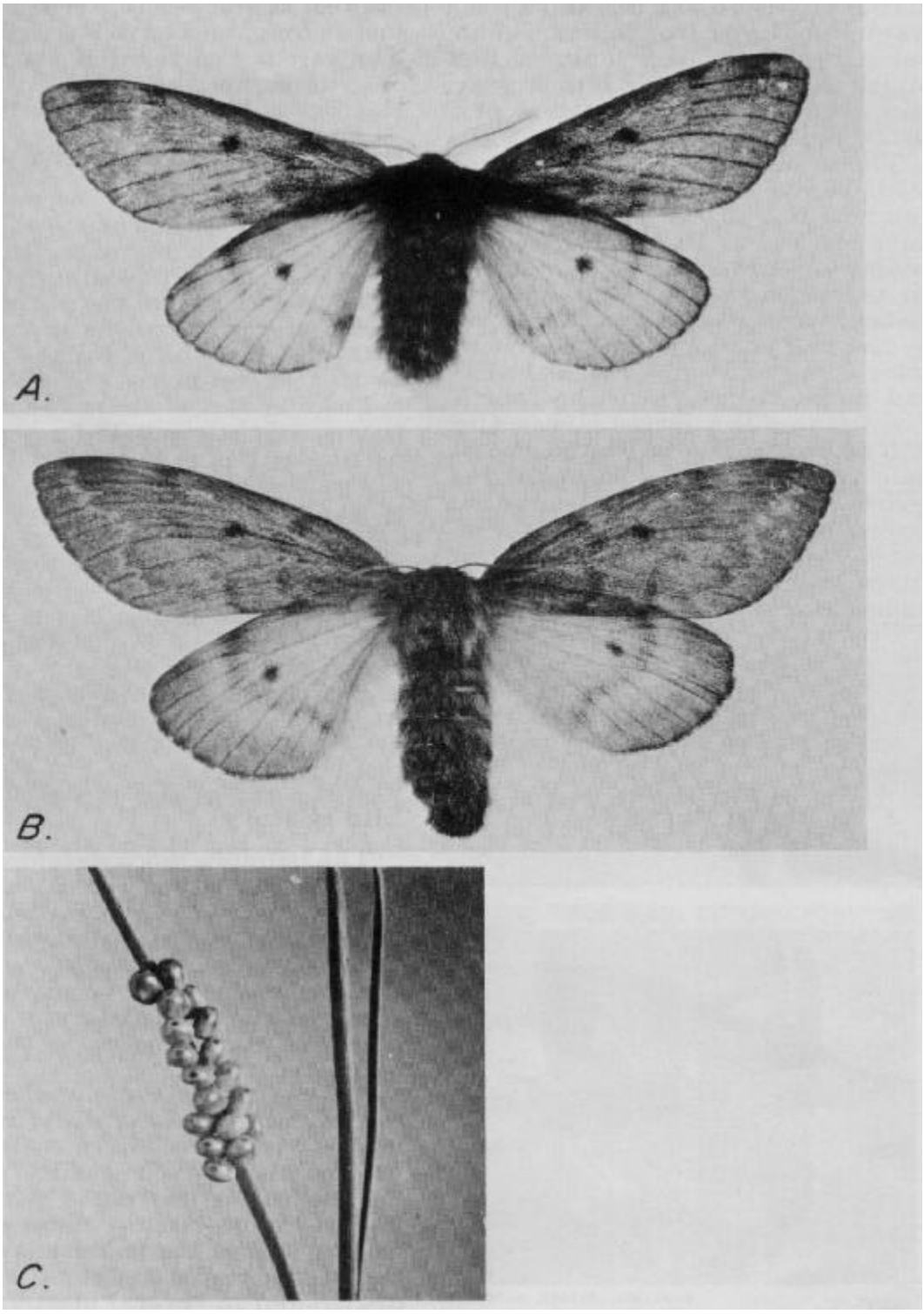

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Figure 2.—Life stages of the pandora moth: A, Adult male (X 1.2); B, adult female (X 1.2); C., eggs (X 2)

deposited in clusters of 2 to 50 (fig. 2, *C*).

There are five larval instars and all have characteristic spines. Larvae hatching from eggs (fig. 3, *A*) have black shiny heads, black spiny bodies and are about one-fourth of an inch long. In the second to fourth instars, the upper surface is, marked by two narrow white lines, and body color changes from black in the second instar to brown in the fourth. The fifth or last instar larvae (fig. 3, *B*) have orange-brown heads and pale yellow-brown collars; at first bodies are blackish, then olive brown, marked by transverse yellow bands and a longitudinal white stripe. They grow to be 2¼ to 3 inches long.

Pupae (fig. 3, *C*) are stout, dark reddish or purplish brown, 1 to 1½ inches long, and have a tough shell. They are not enclosed in a cocoon of any kind, and all body parts are clearly visible.

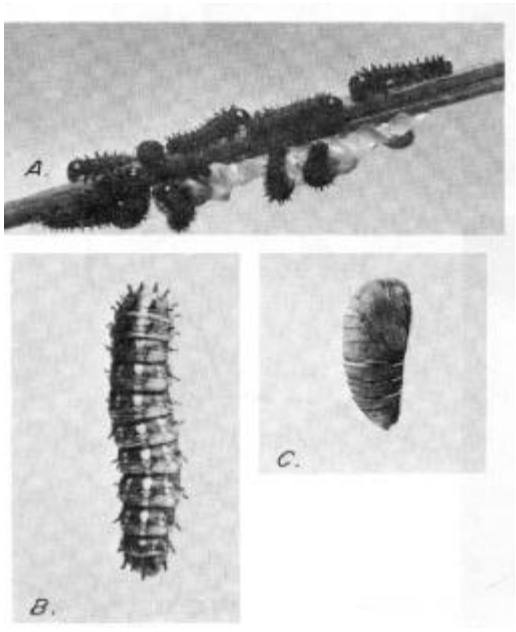

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Figure 3.—Life stages of the pandora moth: A, Larvae hatching from eggs (X 2); B, last-instar larva (X 0.7); C, pupa (X 0.6).

Evidence of Infestation

Heavy defoliation occurs only every other year, when feeding by large larvae takes place. In these alternate years, if feeding is heavy, stands viewed from the air are reddish. Later, tree crowns appear thin with the remaining foliage chiefly at tips of branches (fig. 4).

Feeding larvae are easy to detect because of their size. If feeding populations are present, larvae or stubs of needles and cast larval skins (fig. 5) can be found on small trees.

Once larvae become large, greenish or brownish droppings under infested overstory trees indicate their presence. Full-grown larvae may be found crawling down tree trunks or wandering on the soil surface. Moth flights to lights of nearby towns are sometimes the first indication of an upsurging population of pandora moths.

Life History

The pandora moth develops from egg to adult usually in 24 months. Most moths of the generations studied to date appear in the even-numbered years, although off-year flights occasionally occur. In one area of southern California, principal moth flights occur in the odd-numbered years.

Moths emerge from pupal cases in the soil late in June or July, depending on the area. Males search out the females, which usually do not fly until after mating. A period of 24 to 48 hours usually elapses after mating before the females lay eggs. Females lay an average of 80 eggs, distributed in several clusters, usually on needles and bark of

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Figure 4. —Lodgepole pines defoliated by larvae of the pandora moth. (Arapaho National Forest, Colo.)

pines and occasionally on ground litter or brush. Eggs hatch during August after an incubation period of 40 to 50 days.

The small larvae first feed on yolk left in the egg shells, then move to and feed on the needles of branch tips as a discrete group. In moving from one feeding site to another, larvae travel together in single file. In Oregon and California, the colony-feeding habit (fig. 6) is maintained until late fall, when larvae disperse and feed individually. But in the

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Figure 5.—Stubs of needles and cast larval skins are evidence of pandora moth feeding.

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Figure 6.—Pandora moth larvae feeding as a colony in fall in central Oregon.

Rocky Mountains, larvae disperse earlier in fall. They overwinter at the base of the needles, usually amidst a few silken strands. Up to the overwintering period, larval development varies with the region. In the Rocky Mountains, larvae overwinter mostly in the second instar; in Oregon and California, mostly in the third.

In spring, with the onset of warm weather, larvae resume feeding as early as April in Oregon and California, but later in the Rocky Mountains. In Oregon and California some feeding occurs in winter on warm days. During the spring-feeding period, larvae grow rapidly, consuming an enormous quantity of needles. On ponderosa pine with favorable temperature conditions, each larva at first consumes 1.5 to 2.0 needle bundles per day but, eats five to eight bundles per day in the last instar. During this spring period, needle growth of all ages is eaten: the buds, however, are not damaged. When fully grown, larvae crawl down the tree trunks and enter the soil to pupate. In Oregon and California pupation commences in June; in the Rocky Mountains, where spring feeding begins late, pupation is in July and early August.

Pupae are formed in a cell in loose

mineral soil, where they remain for about a year. In some areas at least, a substantial part of the generation remains in the soil for 2 years, and some individuals for 3 and 4 years.

Natural Control

The pandora, moth has many natural enemies, some being directly responsible for suppressing outbreaks. In Colorado, one of the most important is a wilt disease (probably a polyhedrosis virus). It infects mature larvae; they become limp, turn orange brown or black, and shrivel to about one-third of their normal size. A wilt disease that kills pupae has also been recorded in the Rocky Mountains.

Predation on pupae by rodents, such as ground squirrels and chipmunks, is also a major control. It is of more importance in Oregon and California, where pupae are available as food about 3 months in the summer, than in the Rocky Mountains where availability is only 6 to 8 weeks before cold temperatures restrict predator activity. Diggings for pupae by these rodents are often quite conspicuous.

Birds feed somewhat on the pandora moth. Creepers and nuthatches feed on the egg clusters, at times destroying large numbers. Steller's jays and vireos feed on the larvae. However, some other species of birds seem to be repelled by the spines on the larvae. In the Rocky Mountains, robins have been observed knocking female moths to the ground, then severing and swallowing the moth abdomens. Viable pandora moth eggs have been recovered from robin feces.

Insect parasites are also of some importance in reducing pandora moth populations. Three species are known to attack pandora moth eggs and at least six others attack larvae. Of the latter, only the tachinids that parasitize spring-feeding larvae are of particular importance.

High temperatures of the soil surface when larvae are entering the soil for pupation can cause high larval mortality. In 1939 such conditions were significant in terminating an outbreak in Colorado.

Applied Control

Direct control measures using insecticides have not been devised, since natural control usually suppresses outbreaks before tree-kill occurs. Because of the exposed feeding habit of the insect, stomach poisons as well as contact insecticides should be effective. Nonpersistent insecticides of low mammalian toxicity are likely candidates for testing. Microbial insecticides, such as an indigenous virus and *Bacillus thuringiensis* Berliner, offer promise for control; initial tests with *B. thuringiensis* have been encouraging.

Some Indian tribes collected and used pandora moth larvae and pupae as food; in so doing, these tribes must have effected some direct control in localized areas. The Piute Indians near Mono Lake, Calif., smoked the caterpillars out of trees by means of smudge fires and trapped them in trenches. Larvae were dried and cooked with vegetables in a stew, called "peage." The Modoc and Klamath Indians collected and roasted pupae, which were called "bull quanch" and considered a delicacy.

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