United States
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Agriculture

Animal and
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Inspection
Service

Plant Protection
and Quarantine

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New Pest Response Guidelines

Lymantriidae

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CONTENTS

PURPOSE AND DISCLAIMER

These New Pest Response Guidelines indicate how to survey for and control tussock moths.

They may aid States in developing action plans. The procedures were developed by staff members of Plant Protection and Quarantine (PPQ), Plant Protection Laboratories (PPL) through discussion, consultation, or agreement with other Animal and Plant Health Inspection Service (APHIS) staff members, the Agricultural Research Service (ARS), Forest Service, State, private and University advisors.

This document is not exhaustive. It summarizes available literature. Some articles may not have been seen, nor have all pertinent specialists and other members of the research community been consulted for their advice.

GENERAL INFORMATION

Action Statement

The information contained in this document is intended for use as guidance in designing a program to detect and respond to an infestation of tussock moths in the Family Lymantriidae. Any of the species of these moths could cause untold millions of dollars in damage to forests, commercial crops and other hosts in areas where they are newly established.

The risks entailed would depend on the geographical areas threatened, the hosts involved, the potential new hosts present and the interaction of the invading pest with the local biota. It is assumed here that by the time of discovery of an invading pest, the interaction between it and the local environment would provide some information as to the potential seriousness and impact the pest may have, and for which resources would have to be directed to avert or alleviate such consequences (See also "**CONTROL PROCEDURES**," "No Action."

These New Pest Response Guidelines provide information on implementing detection, control, containment, or eradication programs. Specific emergency program action must be based on information available at that time.

Background program framework and information for these Guidelines came from previous APHIS documents as contained in the Guidelines and Action Plan series. This was modified and reinforced by documents pertaining to specific action against certain tussock moths. These documents are: APHIS and State Programs for Gypsy Moth (Anon., 1990; USDA, 1992; Anon., 1995; CDFA, 1989); The Operational Field Trials (Anon., 1980) and the Defoliator Management Guidebook For Douglas-Fir Tussock Moth (Anon., 1996); Operation Evergreen (1996) For the White-Spotted Tussock Moth; and The Control of the Brown-Tail Moth (Casco Bay Online, 1996; Maine Forest Service, 1999). Some of the above references may not be specifically cited in the text because APHIS program actions may encompass and even exceed those parameters given in these references. Specific references to sources of information are otherwise made throughout the text.

Initial Program Procedures

The following steps will assist in initiating program efforts.

Step 1--Identification and Detection:

Several options are available for identification and detection programs. Options which may be used are given in "**IDENTIFICATION PROCEDURES"** and **"SURVEY PROCEDURES**" and Addenda 4 and 7 of this document.

Step 2--Scoping the Problem:

The extent of the infestation and the difficulties faced by program managers will be determined through surveys and a determination of the biological (See Addendum 7, Life History) and practical realities in advance of any active program.

Step 3--No Action to Eradication:

The effectiveness of the various control options will be considered, including regulatory actions (See "**REGULATORY PROCEDURES"**), available options for control or suppression of the vector population, and destruction or treatment of the hosts (See **"CONTROL PROCEDURES**" and Addendum 5). From this information, and in the light of available resources, a decision must be made to either take no action (a program is impractical), or to control, suppress or eradicate the target population if possible (See "**CONTROL PROCEDURES,"** "No Action," and "Recommended Pesticides."

Background Information

Tussock moths are a family of moderately sized moths, mostly of drab or white coloration, hairy and heavy-bodied. The females of many species are wingless. Many females bear a thick anal tuft of scale-hairs used to cover the egg mass after oviposition. Others may use no hairs and insert eggs under bark scales or leave them completely exposed. The larvae are stout-bodied, bristly caterpillars, often with bunches of hairs or tussocks, and may be strikingly colored. Tussock moths are general defoliators and many species are polyphagous. Most species are damaging to forest trees, but some feed on fruit trees and various woody shrubs. Examples of some of the more important pest species are:

Dasychira mendosa - Polyphagous; India and Southern Asia, Australia (Ironside, 1980)

Euproctis chrysorrhoea - The brown-tail moth; polyphagous; Europe, Asia, USA (Hill, 1985)

Euproctis fraterna - Plum hairy caterpillar; polyphagous; India (Hill, 1985)

Euproctis pseudoconspersa - Tea tussock moth, Japan (China - Wang, 1981)

Lymantria dispar - Gypsy moth; polyphagous; Asia, Europe, North America (Hill, 1985)

Lymantria lapidicola - Almond tussock moth; Asia Minor (Hill, 1985)

Lymantria monacha - Nun moth; polyphagous; Europe and Asia (Hill, 1985)

Orgyia antiqua - Vapourer moth; polyphagous; Europe and Asia, Chile (Santis et al.,1979)

Orgyia pseudotsugata - Douglas-fir tussock moth; Western United States (Brooks et al., 1978)

Perina nuda - Fig tussock moth; India, SE Asia, China (Hill, 1985)

Life Cycle Information

Insect development is temperature dependent. There is a minimum temperature threshold below which no measurable development takes place. A developmental model that uses modified air temperature data for all life stages can be used to predict the entire life cycle. The temperature for these developmental thresholds has been determined for a number of Lymantriidae. The number of degrees accumulated above the developmental threshold for a life cycle are called day degrees (DD). One day degree is 1 day with the average temperature 1 degree greater than the threshold for development.

Caution should be exercised in the use of DD models for any species. For example, the thermal limit for egg hatch may be reached in thinned stands of trees 7-10 days earlier than eggs in unthinned sites with less solar warmth (Wickman & Torgersen, 1987).

Another note of caution covers pupal development. As far as is known, lymantriids do not pupate in the soil. However, depending on the species, they sometimes shelter in protected places which might influence development.

Genetic variations may also occur, such as hybridizations between conspecific varieties or subspecies. This hybridization has happened between the Asian gypsy moth and the gypsy moth in Europe in the fields and in North America. In laboratory studies, the development rates are faster for these hybrids, thus forcing revisions to life cycle calculations.

For the air temperature model depicted in the table below, a specific number of DD must have accumulated before a life cycle is completed. Threshold temperatures are usually tailored to the species involved. See Addendum 7.

Day Degree Calculations

Formula:

Minimum Daily		Maximum Daily		Total		Average Daily	Thresholds	Day Degrees
Temp °F	+	Temp °F	=	Temp °F / 2	=	Temp °F	- Temp °F	= # of DD

Example for Lymantria dispar: (Air temperature model using a 45.77 °F threshold limit).

Minimum Daily		Maximum Daily		Total		Average Daily	Thresholds	Day Degrees
75 °F	+	86 °F	=	161 °F / 2	=	80.5 °F	- 45.77 °F	= 34.73DD

The known developmental thresholds and accumulated DD for those lymantriids for which such data are known are given in Addendum 7.

Most lymantriids do not have such details on day-degree accumulation. In the absence of these data for a particular species, one can use the averages or the most applicable figures taken from known data and extrapolate to the target pest. The averages and applicable figures are:

Average Of All Lower Thresholds:	49.46°F (9.7°C)
Average Of All Total DD:	1095.3 DD in °F (590 DD in °C)
OR	
Highest Lower Threshold:	59.1°F (15.1°C)
Highest DD Accumulation:	1229 DD in °F (665 DD in °C)

It should be noted that for program purposes, the lowest known thresholds and highest DD accumulations are generally used. This is to permit variations in developmental time, which may be caused by host or micro climatic factors. In addition, many species inhabiting temperate regions undergo periods of arrested development, usually for the purpose of hibernation. In most species, diapause occurs in the egg stage, but a significant number enter hibernation during the larval stage, overwintering in nests or hibernacula.

The life cycle biology for those species for which information is known is summarized in the table below. This data is useful in the design and development of a program for a given lymantriid species.

To the extent possible, some comparisons between different related species can also be made from this table. In addition, it may be possible to derive some general overall guidelines for a lymantriid for which no or few details are known.

Life Cycle and Biology of Various Lymantriidae Species

Species	Over-wintering Stage (See Addendum 7)	Tropical / Temperate (See Addendum 7)	Hosts (See Addendum 3)	Flight & Dispersal Characteristics (See Addendum 7)	Day Degree Thresholds (See Addendum 7)	Life Cycles (See Addendum 7)
Calliteara cerigoides	---	Tropical	*Shorea javanica* *Hopea odorata*	---	---	Egg-Pupa 17.4-19.4 days
Calliteara pudibunda	Pupal stage	Cold-temperate to temperate	Deciduous Trees/Shrubs	April-May July-August At night	---	Egg hatch in 21 days
Dasychira horsfieldi	---	Temperate	Apple	---	---	Egg-Adult 58-78 days
Dasychira mendosa	---	Temperate to tropical	Trees, Bushes, Vegetables, Citrus	---	---	27 - 66.5 days
Euproctis bipunctapex	---	Tropical	Polyphagous	---	---	---
Euproctis chrysorrhoea	Larval stage	Temperate	Fruit trees, Shrubs, Deciduous trees	End of June-early August. At night.	---	One Generation a year
Euproctis fraterna	---	Tropical/ Temperate	Fruit trees	---	---	Egg-Pupa 40-45 days (short duration larvae); long duration is 99-128 days
Euproctis lunata	---	Tropical	Deciduous trees, millet	August to November. Emerge in evening.	---	Life cycle 52 days; 3 generations between August-April
Euproctis melania	Larval stage	Temperate	Oak, Apple, Pear	---	---	---
Euproctis scintillans	---	Tropical	Beans	---	---	Egg- Adult 37-43 days
Euproctis similis	Larval stage	Temperate to Cold-temperate	Forest trees, Fruit trees, Ornamentals	July-August. At night.	---	One generation a year
Euproctis subnotata	---	Tropical	Sorghum, Tea, Cashew, Pea	Emerge in the evening.	---	Life Cycle is 43-58 days
Euproctis taiwana	---	Tropical	Beans, Grapes, Gladiolus	---	Egg- male 1024.7 DD (F) Egg- female 1155.2 DD (F)	egg - male 36 days egg - female 41.5 days
Gynaephora spp.	Larval stage	Boreal	Forage Grasses	Diurnal	---	Frequently multiyear

Species	Over-wintering Stage (See Addendum 7)	Tropical / Temperate (See Addendum 7)	Hosts (See Addendum 3)	Flight & Dispersal Characteristics (See Addendum 7)	Day Degree Thresholds (See Addendum 7)	Life Cycles (See Addendum 7)
Heteronygmia dissimilis	Pupal stage	Tropical?	African Mahogany	Nocturnal	---	Egg - Adult 41-45 days
Ivela auripes	Egg stage	Temperate	Dogwood	Diurnal. June-July	---	Development optimal at 30°C - larvae 25-30°C-pupae
Leucoma salicis	2nd Instar	Temperate	Poplar, willow	Mainly nocturnal. Early July.	---	Three generations a year
Leucoma wiltshirei	2nd, 3rd, 4th Instar	Temperate	Oak	---	---	Three generations a year
Lymantria ampla	---	Subtropical	Cotton, Cocca, Cashew, Casuarina spp.	Female flightless	---	---
Lymantria dispar	Egg stage	Temperate	Fruit trees, Forest trees, Many others	July -September Male Diurnal. Sub spp. Female winged. Larva use silken threads.	Egg to adult Low - 815.4 DD High- 1186 DD (In °F)	Egg - Pupa 1½ - 3 months Pupa - Adult 1 - 2 months
Lymantria marginata	---	Subtropical	Chinese Chestnut, Mango	Nocturnal-- peaks 4 hours before sunrise.	---	Egg - Female 61.6 days Egg - Male 46 days
Lymantria mathura	Egg stage	Cold-temperate	Hardwoods, especially Oaks & Beeches	Larva use silken threads.	---	---
Lymantria monacha	Egg stage May overwinter repeatedly	Cold-temperate to temperate.	Fir, Birch, Larch, Pines, Oak, Beech, Spruces	Male flies at night - Female hardly ever. Flight at dusk, another peak at 1-2 pm	---	One generation a year
Lymantria obfuscata	Egg stage	Temperate	Forest & Ornamental Trees Fruit trees	Female flightless	---	One generation a year
Ocnerogyia amanda	Last larval stage - emerges as adult	Temperate	Fig	---	---	Three to four generations a year
Orgyia antiqua	Egg stage	Cold Temperate to Temperate	Forest trees, Fruit trees, Cucumber, Hops, Roses, Berries	Males fly females do not fly. May-June, August, Sept.-October	---	Three generations a year Egg - Adult 35- 53 days
Orgyia gonostigma	2nd-3rd Larval Stage	Temperate	Fruit trees, Forest trees	---	---	---

Species	Over-wintering Stage (See Addendum 7)	Tropical / Temperate (See Addendum 7)	Hosts (See Addendum 3)	Flight & Dispersal Characteristics (See Addendum 7)	Day Degree Thresholds (See Addendum 7)	Life Cycles (See Addendum 7)
Orgyia leucostigma	Egg stage	Temperate	Fir, Birch, Walnut, Sycamore, Corn (??)	Female wingless	---	---
Orgyia postica	---	Temperate to Sub-Tropical	Beans, Cocoa, Mango, Roses, Grapes	Female wingless	Egg - Male 1073.8 DD Egg - Female 1183 DD (In °F)	Egg - male 34 - 35 days Egg - female 37 days
Orgyia pseudotsugata	Egg stage	Temperate	Fir, Spruce	Males fly; females do not fly. Larva use silken threads.	---	Egg -Adult 43. 127 days depending on Temperature
Orgyia thyellina	Egg stage	Temperate	Fruit trees, Birch trees, Oak, Geranium, Willow, Wisteria	Males & females fly in summer at night; male only in fall, flying at dusk	Egg - Adult Low = 1155 DD High =1229 DD (In ° F)	Two to three generations a year
Pantana sinica	Pupal stage	Temperate	Bamboo	---	---	Three generations a year

Program actions are governed in part by insect life cycle data. Control, suppression, and eradication treatments, length of survey activities, and regulatory functions are affected by key events in the insect's life cycle.

Temperature data are available from the National Oceanic and Atmospheric Administration (NOAA), the U. S. Department of Commerce, private, State, university, or industry sources, or from remote site weather monitoring stations run by any of the above.

Program planning must anticipate and incorporate events that shorten or lengthen the life cycle.

IDENTIFICATION PROCEDURES

Introduction

Correct and proper identification of the pest is the key to determining if an action program will be attempted, and if so, the extent, direction, and magnitude of the program, which must be cost effective and environmentally acceptable. Continued identification services during the course of a program will help determine program changes and program failures.

Identification Characters

Some sorting can be done by field personnel assigned to a program. In general, a description of the target species with pictures and drawings should be prepared for the program. This should include distinguishing features which separate the target lymantriid from indigenous species.

General Description of the Lymantriidae

Eggs: Generally spherical, hemispherical or subcylindrical, surface unsculptured. Commonly deposited in large masses, covered or intermixed with hairs from the female abdomen, or with a hardened, frothy substance, or both. Eggs of Dasychira spp. are deposited singly or in small groups without covering, eggs of Orgyia spp. are deposited in a mass on the surface of the cocoon from which the flightless female emerged (Ferguson, 1978). Wingless females of some species never leave the cocoon and lay eggs within (Schaefer, pers. comm.).

Larvae: with all legs fully developed and with abundant, long, secondary hair, often intermixed with fine, needlelike spines, arising in clumps from addorsal, subdorsal, supra- and subspiracular and subventral verrucae; with or without two anterior and two or three posterior hair pencils of long plumose hairs and low dense dorsal tufts on at least the first four abdominal segments; two colored (pale yellow to red) dorsal glands on abdominal segments six and seven; integument sometimes with brightly colored markings; head smooth, shiny, with numerous fine setae (Ferguson, 1978).

Pupae: Pupa conspicuously hairy, the setae at scars of larval verrucae very long, may be on sculptured eye-piece and gena; labial palpi usually visible, maxillae short, not more than 2/5 of wings; no epicranial suture; femora of prothoracic legs not visible; distinct cremaster with hooks (Nakamura, 1976; Ferguson, 1978).

Adult: A tendency towards flightlessness in the female is prevalent in the Lymantriidae. Even with fully developed wings females may be too heavy- bodied to fly or may have greatly reduced wings or are even virtually wingless in some species. Adults also have reduced mouthparts and are incapable of feeding.

Adults assume a characteristic resting posture by which they may be recognized, especially the male which assumes a broadly triangular shape with wings flatted and closely appressed against the substratum and densely hairy forelegs extended forward in front.

Adults may usually be recognized by the following characters:

- Venation of the hind wing, in which the base of M_2 is much closer to M_3 than to M_1
- The absence of the haustellum and of ocelli
- The presence of a prespiracular counter-tympanal hood
- For males, one to three long, divergent spinules at the end of each antennal segment.

(Ferguson, 1978)

Collection of Specimens

As many specimens as possible of the pest should be collected for screening-identification by the local designated identifier. Initial or preliminary identification may be carried out by field personnel (see Chart).

Handling of Adults

Suspect adult specimens collected from sticky traps should be handled carefully. The following procedures are recommended to insure that specimens caught in sticky material can be identified accurately:

1. Ship entire trap. Pin the trap in a pinning box suitable for mailing. Place it in a second shipping box and put filler between the two boxes.

OR

2. Cut out a portion of the insert or trap wall surrounding the specimen. This will leave you with the specimen imbedded in sticky material on a small piece of cardboard. Put an insect pin (number two size) through the cardboard and pin the cardboard (with specimen attached) in a pinning box suitable for mailing. To ship the pinning box for identification, place it inside a second shipping box and put filler between the two boxes.

Handling of Larvae

Suspect larvae should be killed by placing in water, bringing to the boiling point, cooling, and then preserved in 70-75 percent ethyl alcohol.

Shipping

Larvae and adult specimens should all be forwarded, along with any other insect stages that have been collected, for confirmation to the designated area identifier (see following chart). All specimens must be accompanied by collection information:

- Collector's name
- Address
- Phone number
- Date collected
- Location
- A Pest Interception Form (PPQ Form 391) marked "Urgent".

The identifier's office should be telephoned prior to shipping specimens to alert him/her of the shipment.

Information Flow for the Identification of Specimens

Specimens Collected

↓

Screening/identification by State or PPQ Laboratory (Mandatory) — Designated Area Identifiers

↓

Specimen Submitted for Confirmation by State or PPQ Laboratory — Leader, Taxonomic Services Unit; USDA, ARS, BA, PSI; Building 046, Room 101A, BARC-EAST; Beltsville, MD 20705-2350

↓

Confirmation Notification to Requesting Party and to Other USDA Agencies — State and Territory Agricultural Regulatory Officials

↓

Results Sent to APHIS and if Exotic, Information Relayed to North American Plant Protection Organization

SURVEY PROCEDURES

Introduction

The purpose of a survey is to determine if a pest is present and the extent and means of pest spread. Conversely, it is also used to determine pest-free areas. Human and natural means of dispersal should be considered. Dispersal must be factored into survey design.

Surveys should be custom-designed, depending on the advice of a Scientific Advisory Committee. This committee must consider critical factors such as host distribution, flight activity and wind patterns, etc. Survey procedures will vary depending on the lymantriid species involved and the availability of a pheromone. To help determine the outlines of a good survey system, a table listing known life features of many lymantriids, their pheromones, and possible traps is given in Addendum 4.

There are two primary survey methods: trapping and visual. Used together, these can increase the effectiveness of the survey.

Detection Survey

For lymantriid species which do not have females capable of flight, the detection survey will extend for: 1) up to 10 miles beyond the delimiting survey and/or, 2) up to 1 mile inland along waterways and both sides of major roads leading to a port or other suspect site.

For lymantriid species with females capable of flight, the detection survey will extend up to 30 miles (or 70 miles for fully alate, powerful female fliers - see Addendum 7) beyond the delimiting survey and/or up to 5 miles inland along waterways and both sides of major roads leading to a port or other suspect site. (USDA, 1992)

The number of traps assigned to a given area, such as along roadsides, must be within reasonable, achievable goals (USDA, 1995), depending on resources and funding available. Such traps may be spaced as determined by a technical advisory committee:

Trapping Rate for Early Detection

- At a minimum rate of one trap every 10 acres (1 trap/4.5 hectares) for early detection of isolated low-density populations.

Areas to Cover for Early Detection

In addition, the National survey by all other area, State, regional, and national survey programs, may enhance the detection survey insofar as it is possible.

There are three types of areas to cover in this survey: Risk Areas, Special Sites and Host Production Areas. Each area needs to be evaluated in light of the risks from the target lymantriid species in question. For example, these are the risk categories and the trapping rates used in the national Gypsy Moth Survey. This is included as a guide.

Risk Areas:

Category 1--High Risk—Depending on the target species, the following areas have a high potential for introduction of a lymantriid:

—Inland Areas:

- Major cities and towns where residents and visitors may be expected to travel to and from areas where the lymantriid already exists.

- People moving from, or regulated articles (see **"REGULATORY PROCEDURES,"** "Delimiting Survey") moving from infested areas into noninfested areas. Such areas include the following:

  –Suburban residential areas with abundant hosts.

  –Affluent residential areas.

  –Residential areas with a high volume of relocations.

  –Cities with military bases or major universities.

  –Recreational sites, especially those with ≥ 4,000 recreation visitor days (Antrobius, 1990) (Figures available from National Park Service or other authority).

  –Major universities where exotic host material is imported.

  –Areas exposed to host disposal.

—Port Areas

- Port areas exposed to wind-blown larvae or flying females.

- Ports of entry where high risk transport visiting or passing through infested areas or endemic areas of origin have subsequently stopped.

- Transect areas, such as waterways, major roads, rail car consolidation areas, devanning, CES, and Customs examination sites for such transport may also be a high risk.

Trapping Rate for High Risk Areas

Traps, if employed, should generally be set at 4 to 9 per square mile on a grid system, depending on the target species, lure attractantcy, and other variables.

Category 2--Moderate Risk—Depending on the species, areas with moderate potential for introduction of the lymantriid and with suitable hosts present are the following:

—Contiguous host areas that are accessible to people

—Areas with moderate populations such as small cities

—Large urban areas with limited habitat

Trapping Rate for Moderate Risk Areas

Traps, if employed, should be generally set at four traps every square mile on a grid system.

Category 3--Low Risk—Areas with a low risk of introduction of the lymantriid and with suitable hosts present. These areas include the following:

—Rural agricultural areas with widely scattered small towns

—Noncontiguous host areas

Trapping Rates for Low Risk Areas

Traps, if employed, should be generally set at one trap every 4 square miles (0.25 traps per sq mi.) on a grid system.

Category 4--Nil Risk—Areas with no hosts (often due to lack of habitat) or potential for introduction.

—No Action for Nil Risk Areas

- No action will be taken in such areas.

Special Sites:

There are several categories for Special Sites. Any effort expended on surveys in these areas should not be at the expense of regular program needs.

Category S_1–Artificial Areas

Sites where infestations are most likely to be artificially introduced. These are sites that have a history of receiving regulated articles from areas where lymantriid infestations exist. These sites may also be presumed to receive such articles based on their nature or use. They may also be exposed to movement of possibly infested vehicles from infested areas. These areas include, but are not limited to, the following:

- Establishments handling regulated material
- Nurseries
- Mobile home parks
- State and Federal Parks
- Campgrounds
- Tourist attractions (including recreational sites logging 4,000 recreation visitor days (Antrobius, 1990). (Figures available from National Park Service or other authority.)
- Factories receiving containers
- Importing establishments

Category S_2–Windward Areas

- Those areas where winds may reasonably be expected to carry the lymantriid from areas where it already exists.
- If there is significant wind movement due to low pressure areas during adult dispersal, it is possible that adult moths or first instar larvae from an infested area could be drawn toward such a system. A downdraft could deposit these stages over a relatively small area a considerable distance from the infested area. The lymantriid could also be freed when winds die down in the evening.

If such a system occurs during moth flight times, or anytime when first stage larvae are present, then exposed downwind localities with hosts should be surveyed. This should be done in 3 to 4 weeks or longer, allowing any presumed moths time to settle and develop another generation to the point where they can be more readily detected by survey means (APHIS, 1985; see also Taylor & Reling, 1986).

Trapping Rate for Special Areas

- Traps, if employed, should be set at a rate adequate to detect populations when small, for example gypsy moth would use a rate of ≤ four traps per site or per square mile.

Commercial Host Production Areas:

Those areas where commercial hosts are grown.

—Trapping Rate for Commercial Areas

Trap density should consider trap efficacy range and male behavior. For gypsy moth, for example, traps would be set at a rate of no more than four traps per square mile.

Delimiting Survey

When one or more target pest finds are confirmed in an area, a delimiting survey of up to 4 miles beyond the core area for lymantriid species without females capable of flight, and up to 20 miles for lymantriid species with females capable of flight, should be implemented immediately to determine the population distribution.

A delimiting survey is necessary to find the extent of an infestation (Boundaries and Focal Point) and in addition, the intensity of the infestation. There are several types of surveys which may serve this purpose:

Transect Surveys:

Transect Surveys are recommended as a rapid delimiting survey for lymantriids. They may also be used in support of a delimiting survey.

Cross-Transect Survey--Cross-transect surveys (see **"SURVEY PROCEDURES,"** "Detection Survey," and Addendum 4) are recommended. This type of survey is essentially two lines drawn through the epicenter of the find and through as many host areas as is possible, as far as the limits of the delimiting survey area.

Leap Frog Survey--This type of survey is essentially to locate and survey at least all the most promising host areas in the delimiting survey area.

Radial Survey--This survey technique involves drawing a series of four to eight lines transecting the epicenter and radiating to the limits of the delimiting survey area. All host areas along these lines will be surveyed for the presence of the target pest.

Grid Surveys:

Grid surveys are labor intensive surveys which require breaking the delimiting survey area into a number of equal sized square areas (grids), the size dependent on the type of grid survey chosen. A survey of hosts in each grid is then carried out.

Uniform Grid Survey--A grid survey in which a survey for the target pest is carried out at a uniform rate, intensity and times for each grid.

Intensive Survey--An intensive grid survey which may be carried out:

- Block by block
- Property by property
- Host by host
- Intensive trapping

Biometric Survey:

A survey which combines valid statistical procedures with known biological information to determine the most likely areas and/or hosts where the target pest may be found, and surveying in those areas.

If needed for an immediate response, the APHIS Rapid Response Team and other Federal, State and local units should be considered as resources when planning a delimiting survey.

Using the site of the detection as the epicenter (focal point), the survey should employ the following methods to delimit the extent of the infestation:

The delimiting area for Category 1 will be 1 to 4 square miles in extent, unless evidence is available that a larger area is infested. The delimiting area for Categories 2 and 3 will be 1 to 2 square miles, unless there is evidence that a larger area is infested.

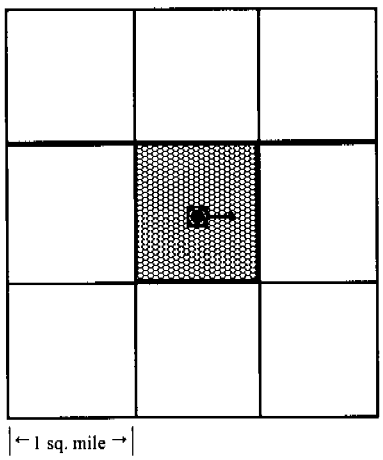
Traps in all delimiting areas should be set at a rate which will detect reproducing populations per square mile in a grid arrangement, depending on conditions and the judgement of a Scientific Advisory Committee.

Variables in trap density to consider are:

a. Duration of infestation
b. Movement of high-risk materials
c. Ability to disperse

In gypsy moth (GM), for example, the GM program uses 16-32 traps/sq. mile. Below is an example of a delimiting trap grid.

Delimiting Survey Area In Square Miles:



Core Area = 1 sq. Mile = →
Epicanter = Focal Point =

3-19 mile buffer area

Cross Transect Survey:

A Cross Transect Survey (See Addendum 4) will not be able to define boundaries, however, it will estimate the probable rate of spread. The objective is to estimate the probable distance of spread in the shortest possible time with minimum labor and expense.

The survey described here is biased, as in the detection survey, towards the primary host(s) of concern and in areas where any introduced lymantriid would be expected to be found first. A special survey to track aerial movement during the growing season may be warranted for certain areas.

There are three variables to cover in this kind of survey:

High Risk Areas--Major cities, towns, and recreational sites where residents and visitors may be expected to travel to and from areas where the lymantriid already exists.

Windward Areas--Those areas where winds are expected to carry the lymantriid from locations where it already exists.

Host Areas--Those areas where large amounts of host material are present:

- Commercial nurseries
- Farms where hosts are brought in; for propagation and sale grown for commercial purposes stored for replanting purposes
- Natural areas

Intensive Delimiting Survey:

If a transect survey or another type of survey indicates that the outer boundary has been found, then intensive surveys may begin:

- Conduct a block to block survey in suburban/urban areas up to 1.6 km (1 mi.) from each find.
- In rural areas, conduct a property by property survey up to 1.6 km (1 mi.) from each find.

The intensive survey can be any combination of the following:

—Block by block
—Property by property
—Host by host
—Intensive trapping

- Each block or property can be scored, as can the density of the infestation:

  One suggested ranking:

  —Light The lymantriid is only on one or a few hosts.

  —Medium The lymantriid is on 6 or more hosts.

—Heavy Entire area with numerous lymantriid-infested plant hosts.

The above will permit survey personnel to more accurately plot the extent and nature of the infestation where possible with the help of GPS units, and taking into account such variations as host range and availability of host(s), unequal distribution of infested hosts, and the influence of temperature (i.e., summer) on the numbers obtained.

Each find may be considered a primary site. A primary site is the property on which an initial detection of a lymantriid life stage occurs <u>or</u> a potentially infested site within 1 mile of an infested property, that is, those host areas within the infested area.

A satellite site is a potentially infested property more than 1 mile from any infested property. A satellite site, by definition, can be anywhere except within the 1 mile area around any infested property.

Delimiting surveys will be carried out on all primary sites. They will also be conducted on satellite sites when there is evidence of the possible spread of the lymantriid to or from the infested property. The following conditions define those properties that will be surveyed as satellite sites.

- Any property that has received (within a year) host material or potentially infested material from another infested property.
- Any property that has been the source (within a year) of host material or potentially infested material found on the infested property.
- Any property that is or was the site of visits, especially frequent visits, by persons in conveyances from an infested property.

<u>Video Survey</u>:

A video camera could be productive in finding infestations if the defoliation caused by the target species is distinctive enough to warrant a low-tech aerial survey of host areas. The procedure involves taping a canopy cover with a color video from a low-flying, fixed wing aircraft, so that suspicious areas can be mapped and surveyed on the ground. (Alfaro & Shore, 1984.)

Note that if there are enough larvae present to cause such noticeable defoliation, that the area involved is way past the detection stage and a definite population exists. Such an area will need to be delimited and treated accordingly.

Monitoring/ Evaluation Survey

A decision to suppress or eradicate the target pest will require a monitoring and evaluation survey to check on the pest population. A cross-transect survey is generally employed.

When and where applicable, a sequential sampling system may be used to estimate moderate to low densities of the target species as an aid to decision-making.

Host Collection and Holding

Selected hosts that are collected with eggs or larvae may be held at temperatures and humidity which will permit insect development to the adult stage so that a positive identification can be made (see **"IDENTIFICATION PROCEDURES."**)

Security of the facility where the insects are held must be equal for a quarantine insect-rearing facility as given in APHIS publication, series 81, number 61.

Orientation of Survey Personnel

New personnel will be trained on the job by experienced personnel. A period of up to 3 working days may be needed to do this.

Survey Records

Records noting the areas surveyed, sites trapped, dates, locations, GPS units and hosts in which detections were made, will be maintained.

- Maps
- Chronology of events/action
- Personnel movement
- Meeting notes

Public Relations

All surveys will need the following:

1. Public Outreach Information

    a. Circulars & Flyers--to explain why the pest is important.

    b. ID Cards--to aid in identifying the pest.

2. Public Relations with Industry

a. Affected Industries--contact with those industries, which, even though they do not deal with regulated articles, are somehow impacted by regulatory measures (i.e., transport of goods).

b. Regulated Industries--contact with those industries which grow, sell, make, or transport regulated articles.

REGULATORY PROCEDURES

Instructions to Officers

Regulatory actions should be required until a pest infestation is eradicated or declared established. A Pest Management Team with the advice of the Scientific Advisory Committee, will decide on the scope and extent of regulatory activity if and when suppression and/or control actions are suspended or discontinued. Program personnel will be given instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles.

The instructions and procedures will aid program personnel explaining such procedures to those interested in moving regulated articles.

General treatment instructions may be found in State regulatory manuals, in the APHIS, PPQ Treatment Manual, or in the PPQ Gypsy Moth Manual. These may be helpful in formulating regulatory activities for a newly found pest.

Regulated Articles

Various articles may present direct or indirect risks for spreading lymantriids.

Examples of high risk articles include the following:

- Hosts and host material, such as native and introduced trees and shrubs, ornamentals, and nursery stock
- Firewood, logs, pulpwood, timber, and timber products
- Mobile homes, including RVS, trailers, and campers
- Trees and shrubs
- Outdoor household articles
- Vehicles and other means of conveyance that present a high risk of spreading the lymantriid
- Full or empty shipping containers
- Any other articles and/or products that present a high risk of spreading the lymantriid

Quarantine Actions

Regulatory action will be required if there is a risk of artificial spread as determined by a risk assessment. If:

1. More than one male moth is found in an area less than 6 mi^2 within one estimated life cycle, or

2. A life stage that indicates a reproducing population, or

3. A single moth is found which is determined to be associated with a current eradication project.

When detections are made, the following steps should be taken:

Any Federal regulatory action requires a formal declaration in the Code of Federal Regulations (CFR). The States may issue regulations under less stringent requirements, but may have no authority to regulate interstate movement.

a. State notifications are issued by State field personnel to the property owners or managers of all establishments within 0.5 to 1 mile of the epicenter that handles, moves, or processes host material which may include material and/or conveyances capable of spreading the lymantriid. Notifications will be issued pending authoritative confirmation and/or further instructions from the Head of the State Plant Protection Service and/or the Deputy Administrator, APHIS, PPQ.

b. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Federal Plant Pest Act (7 U.S.C. 150 dd) until emergency regulations can be published in the Federal Register. For information on other legal authorities, see Section II, Parts A and B of the APHIS Emergency Programs Manual (for plant pests).

c. The Head of the State Plant Protection Service and/or the Deputy Administrator of APHIS will notify other State cooperators of the lymantriid detections, actions taken, and actions contemplated.

d. A narrative description of the regulated area with supporting documents should be developed by State personnel. The regulated area will normally be within an approximate 0.5 to 1 mile (mi) radius around the find, and may contain a 1 sq. mi or greater core area where premises may be treated.

e. The State may need to publish an interim rule covering the emergency regulations. The interim rule will announce a date for submitting written comments.

f. After receipt of written comments, a final determination specifying the action decided upon will be published.

Regulated Establishments

Efforts to detect and prevent movement of high-risk articles, including host material, out of the regulated area will be made at locations where host material is grown, sold, handled, processed, stored or moved. Examples of such locations are airports, storage or store areas, landfill sites, fruit stands, farmer's markets, produce markets, flea markets, nurseries, and any other locations that handle or possess regulated articles.

Use of Authorized Chemicals

This New Pest Response Guidelines identifies chemicals effective for lymantriid control, authorized for lymantriid control, as well as methods and rates of application, and any special application instructions. The appropriate State Regulatory Agency must concur in the use of any chemicals or other procedures for regulatory purposes.

Treatment recommendations listed in this Guide are based on uses authorized under provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. Directions appearing on the label, Section 18 Emergency Exemptions, and manual instructions must be followed. Regulated articles may be certified for movement after treatment.

Approved Regulatory Treatments

Some examples of regulatory treatments, which may or may not be used, are the following:

Sanitation:

The removal and destruction of hosts and other regulated items.

Physical Removal:

The removal and destruction of the life stages of the lymantriid.

Steam, Hot Water, or Heat:

The use of heat to destroy any lymantriids present on regulated articles or means of conveyance, storage, or other holding areas.

Fumigation:

The application of an approved fumigant, such as methyl bromide, to hosts or to objects or conveyances.

Chemical Treatments:

—An approved chemical insecticide applied to the above-ground parts of nursery stock to destroy any lymantriids present (See Addendum 5).

—The use of hot soapy water, quaternary ammonium compound, or bendiocarb as a treatment, applied to conveyances, storage or other holding areas, or to host material to destroy any life stages of a lymantriid which may be present.

Principal Activities

The following identifies principal activities necessary for conducting a regulatory program to prevent the spread of an exotic lymantriid. The extent of regulatory activity required will be dependent on the degree of infestation and the behavior and biology of the targeted pest.

Examples of regulatory activities, which may or may not be used, are the following:

1. Contacting and educating the public and affected industries on regulations and required treatment procedures.

2. Issuing compliance agreements, certificates, and permits.

3. Supervising, monitoring, and certifying treatments of host material.

4. Conducting compliance inspections at regulated establishments such as:

   a. Nurseries
   b. Fruit stands
   c. Local growers, gardeners, and packers
   d. Farmers, produce, and flea markets
   e. Farm equipment and implement dealers
   f. Farm and garden supply dealers
   g. Commercial haulers of regulated articles
   h. Public transportation officials
   I. Post office contacts
   j. Canneries and other processing establishments
   k. Storage locations

5. Monitoring the movement of host material to landfills to ensure adequate disposal of regulated articles.

6. Monitoring the destruction of regulated articles to ensure adequate destruction of any life forms of the target pest.

7. Monitoring the movement of regulated articles through airports and other transportation centers.

8. Observing major highway and quarantine boundaries for movement of regulated articles.

9. Notifying homeowners near detection sites of applicable regulations.

10. If applicable, monitoring to insure that only resistant host varieties are planted within the regulated area.

11. Visiting processing establishments, if present, in regulated areas.

12. Monitoring sale and transfer of infested property to insure that property users are aware of restrictions on land use.

Removing Areas from Quarantine

After the target pest has been declared eradicated from a specific area, that area will be removed from quarantine requirements. As a rule, program management will identify areas to be removed.

Orientation of Regulatory Personnel

Only trained or experienced personnel (i.e., Rapid Response Team) will be used initially. All personnel will receive adequate training in all program activities before deployment.

Regulatory Records

Records will be maintained as necessary to carry out an effective, efficient, and responsible regulatory program.

Records may include:

- Maps
- Chronology of events/action
- Personnel movement
- Treatment records of geographic areas such as DGPS files of aerial applications, if applicable
- Treatment records of regulated articles
- Regulatory activities
- Meeting notes
- Certification records

CONTROL PROCEDURES

Under some conditions, eradication or control of a lymantriid infestation is possible and has been accomplished.

Examples include the Gypsy Moth Program in which secondary infestations outside the main generally infested area in the United States, have been eradicated through cooperative Federal-State efforts as well as incursions of the Asian Gypsy Moth, which were eradicated. The New Zealand eradication program against the white-spotted tussock moth, has apparently succeeded in ridding that country of a serious pest.

These programs were successful with the exclusive use of formulations of Bacillus thuringiensis. Due to safety reasons for the public and environment, no other pesticide was considered in the context of these actions. Future programs should keep this option in mind as the primary control measure, if it is* at all useful against the targeted pests.

...*known to be... (See also, Anon., 1995, 1998; Reardon, et al., 1994)

The following provides approved procedures available for use in most situations when a new pest has been detected. These procedures include biological, mechanical, and chemical controls. Local conditions will determine the most acceptable procedure or combination of procedures to achieve suppression, control, or eradication. If treatments selected or proposed are not in compliance with current pesticide labels, an emergency exemption will need to be obtained under Section 18, or 24C, special local need (SLN), of FIFRA, as Amended.

As control procedures are developed, they will be made available to the program. Any Federal participation in direct control programs will be at the discretion of the Agency concerned.

Selection of Options

The selected central method (or methods) will depend on various factors, including:

- The size of the infested area
- The type of habitat (good or marginal for the target lymantriid)
- The type(s) of host available
- The biology and behavior of the target lymantriid
- Biological/chemical control options available
- Cultural options available
- Economic factors
- Socio-Political factors

Program options may be selected through a decision-making process, such as embodied in the decision table immediately below:

LYMANTRIIDAE DECISION TABLE

<table>
<tr><th>If the Finds Are:</th><th>If the Pest Population Appears to be:</th><th>If the Hosts Are:</th><th>Then the Option is:</th></tr>
<tr><td rowspan="4">Established in a large, contiguous area</td><td rowspan="2">In a marginal habitat</td><td>Limited and/or only in well defined areas</td><td>Control, suppression, and/or eradication</td></tr>
<tr><td>Numerous and/or only in well defined areas</td><td>Suppression, cultural and biological controls</td></tr>
<tr><td rowspan="2">In a good habitat</td><td>Limited and/or only in well-defined areas</td><td>Biological and cultural controls</td></tr>
<tr><td>Numerous and/or over an extensive area</td><td rowspan="2">NO ACTION</td></tr>
<tr><td rowspan="2">Present in a number of widely separate and discrete areas</td><td>Well established, as measured by: population estimate, competition, environment, and/or climatological considerations</td><td>→</td></tr>
<tr><td rowspan="3">Not well established and/or population estimates felt to be due to recent (within one year) establishment</td><td>Large number of hosts over an extensive area</td><td>Biological and cultural controls</td></tr>
<tr><td>Present in only one or a few closely separate areas</td><td>Moderate number of hosts over a well-defined area</td><td>Suppression, cultural, and biological controls</td></tr>
<tr><td>Established in a small contiguous area</td><td>Confined to a limited number of hosts and/or in a well defined area</td><td>Control, suppression, and/or eradication</td></tr>
</table>

No Action

Factors involved in arriving at a decision of "No cooperative program action" include the following:

That the lymantriid in question has firmly established itself in the infested area and that:

1. No reasonable effort will be successful in eradicating it (vs. a reasonable effort may be successful);

OR

2. Regulatory and/or suppressive measures will not be worth the cost, since the area involved and/or the rate of spread is too great (vs. affordable measures);

OR

3. On the basis of measurable ecological factors, that the lymantriid will not be present in sufficient amounts in the environment to warrant control or suppression efforts (vs. a serious threat, including threat of movement to a suitable ecological site);

OR

4. Control of the lymantriid is best left to normal means of control (such as host treatment) and other regulatory resources utilized to find ways of controlling the spread and effects of the pest (vs. an urgent need to augment natural controls).

If any of these statements are not true, then a decision to take "No Action" should be carefully evaluated.

Recommended Pesticides

The treatments prescribed are predicated on an adequate survey. At the initiation of a program, an evaluation will be made of available insecticides for use on program operations.

The following is a list of suggested treatments that may be applicable under certain conditions. The treatments selected will be determined jointly by State and local personnel concerned with a given program and their Scientific Advisory Committees or equivalent Advisory Boards. Addendum 5 lists certain additional treatments which may be available.

Records for all treated areas will note the locations, dates, number, and types of treatments. All control records will meet NEPA requirements.

Approved Treatments

1. Insecticides

A number of different categories fall under this heading:

Biological and cultural controls should play as large a role in program efforts as possible. It is worth noting that mortality of larvae in high populations due to predation may be high, accounting for nearly 50 percent in the case of *Orgyia pseudotsugata* in Oregon forests. Early instar larvae were probably preyed upon by insects and spiders and later instars by birds (Mason & Torgersen, 1983). This effect can be enhanced or augmented with other available means such as biopesticides, mating disruption or mass trapping, utilizing strategies such as listed below:

NOTE: For many lymantriids, augmentation of natural enemies is not a tried and true option.

a. Biological Insecticides

Information on the available Biological Insecticides (BI) are given in Table A in Addendum 5. This table, and those that follow, are designed to allow comparisons between different lymantriid species. This arrangement should facilitate decision-making and help in the selection of the best combination of available or known tools.

Table A charts the use of microorganisms against the lymantriids. These include the following categories:

(1). Bacteria
(2). Viruses
(3). Protozoa
(4). Nematodes
(5). Fungi

b. Natural Insecticides

There are also classes of natural substances which can be used to control pest species. For the Lymantriidae, proven natural substances include juvenile hormones, pheromones, and plant extracts. The tables which follow are based on the pest species, the formulation used, and the details provided in the literature.

(1). Juvenile hormones
(2). Insect growth regulators

Juvenile Hormones (JH) or Insect Growth Regulators (IGR) have sometimes been successfully employed to control insect pests.

Table B in Addendum 5 gives those juvenile hormone mimics or insect growth regulators which have been found to be useful.

(3). Particle Films

The use of non-toxic films made of microscopic mineral particles may assist in the protection of hosts in ecologically sensitive areas where chemical applications are not possible or of isolated hosts where they can be thoroughly sprayed with the product. The film results in reduced oviposition and survival on the host. Ground application of the product in homeowner or orchard situations in advance of or around an infested area may reduce the rate of spread and/or populational increases of an invading lymantriid.

The incorporation of biologicals such as Bt or fungi has been tried on an experimental basis, but because the film is both a repellant and an antifeedant, the results have had limited success. A soft contact pesticide like pyrethrums has not yet been tested, but could be more effective. (Pers. Comm., G. Puterka, ARS; Stanley, 1998)

(4). Plant Extracts

Plant extracts have also been successfully used in some cases against a variety of insect pests, including the lymantriids.

Table C, in Addendum 5, gives the known treatments which have been successful against the Lymantriidae.

c. Chemical Insecticides

The table given in Addendum 5 lists the insecticides which have been effective for lymantriids.

Certain studies have shown that some populations or sibling groups of a species of lymantriid differ in their response to chemical treatments. This appears to be due (in part at least) to quantitative differences in esterase isoenzymes. In the event of such a problem, the use of genetic assays in pre-spray population surveys may be advisable (Stock & Robertson, 1979).

Some species may show a preference for congregating in certain areas. Such habits should be exploited whenever possible; i.e., plum hairy caterpillar (*Euproctis fraterna*) congregations on tree trunks and large branches can be sprayed to good effect (Sandhu, et al., 1977).

2. Behavioral Manipulations

a. Mating Disruption

The use of pheromone sprays to control a population. See pheromone disruption techniques in Addendum 5.

Table D in Addendum 5 gives those known pheromones for the Lymantriidae, with an outline of details for their use from the literature.

b. Mass Trapping

The use of large numbers of traps to control a population. See Addendum 5 and Table D in Addendum 5.

3. Biological Controls

a. Introduction of Exotic Natural Enemies.
(Classical Biological Control)

This technique is carried out by USDA, ARS and other Agencies and institutions. APHIS, PPQ is active in implementing classical biological control. The objective is to find and establish exotic natural enemies to help suppress population(s) of the target pest.

Potential parasites and/or predators, whose efficacy would need to be tested are listed in Table E, Addendum 5, by target pest.

b. Augmentation of Predators/Parasites in Infected Area(s).

Augmentation involves mass rearing of the most highly efficient parasites or predators followed by mass release in infected areas. Several techniques for mass release have been developed, such as Beneficial Insect Planes (BIP) (Anon., 1993).

This approach, while attractive from a theoretical viewpoint, has not been used successfully against gypsy moth. Some successes might have been obtained against other lymantriids.

c. Conservation of Predators/Parasites

This treatment refers to the conservation of natural enemies, native or introduced, through integrated procedures with highly selective predator/parasite friendly insecticides or techniques, biological insecticides, and cultural practices favoring predators and parasites.

Details covering several conservational techniques are given in Addendum 5.

d. Enablement of Predators/Parasites

This treatment refers to augmenting the ability of predators and parasites to attack the host with greater efficiency or to be more tolerant of insecticides or other practices through selective breeding of the most efficient predators/parasites. Gene manipulation may also be involved (Hoy, 1989, 1990; Caprio, et al., 1991).

4. Autocidal Control Options

a. Sterile Insect Technique (SIT)

SIT involves the release of large numbers of sterilized males. At this time, sterile release is not an economically feasible option. The only work has been carried out on *Lymantria dispar*. In this species, the females will remate if they initially mate with a sterile male, even if they receive a full complement of sperm. This remating disparity erodes the value of sterile release as an option, and further research is needed (Proshold, 1995).

b. Genetic Manipulation

The genetic manipulation of any of the Lymantriidae has not been sufficiently developed to consider as an option and further research is needed.

5. Other Control Options

The following options, which include environmental, cultural and physical control measures, are meant to enhance any efforts at control.

a. Habitat Manipulation

(1). Patch Complex

A variation of the above, especially for biological forest protection, involves the employment of patch complexes, in which a number of areas are set up inside the entire control area to promote certain ecological situations advantageous for control within the economic constraints of a program. Inside the patch (or area), a complex of increased natural diversity is encouraged. Methods include the introduction of understory tree or bush species, increasing the provision of nesting sites for birds, and the encouragement/introduction of ant colonies such as *Formica neogagates, F. subsericea* and *Camponotus pennsylvanicus*. (Burzynski, 1989; Weseloh, 1994)

b. Host-Plant Resistence

(1). Host Modification

The modification or transformation of selected hosts to reduce larval feeding, including host destruction.

(a) Breeding and Hybridization

These older methods have been more recently tested with hybrid populars of *Populus nigra and Populus maximowiczii.* The feeding rate is indeed reduced, but the techniques take time to develop and are difficult to apply in practice over whole ecosystems. (Kruse & Raffa, 1996)

(b) Transgenetic Engineering

This area is receiving strong attention due to the need for resistant plants in forest and agro ecosystems. A hybrid poplar (*P. alba* x *P. grandidentata*) has been engineered with a *Bacillus thuringiensis d*-Endotoxin gene. In trials, this provided nearly complete protection from gypsy moth, especially in the younger stages. But this technique is subject to evolving resistant pest biotypes (Robison, et al., 1994; Kleiner, et al., 1995).

c. Mechanical

(1). Host Destruction

In situations with a very limited infested area and when the hosts are all herbaceous, vinelike and/or decumbent, consideration may be given to host destruction by:

a. Herbicides,
b. Disking or plowing, and
c. Removal and burial or incineration.

In cases of such destruction, all host material must be completely destroyed.

(2). Burlap Banding

Burlap banding, used as a survey option, may also be used as a control measure. Strips of burlap need to be tied completely around every host tree and large bush, and a perimeter of non-host trees/bushes as well. The burlap should be checked and cleaned out of all larvae, eggs, pupae and adults found on a weekly basis. Any obviously diseased, parasitized or dead lymantriids should be left in place to help along any epizootic or parasites in the target population. If the population is in epidemic numbers and larval numbers under the burlap continue to be high, consider that larvae might be coming from surrounding hosts that have not been banded and extend the infected area accordingly (Liebhold, et al., 1986; Weseloh, 1987).

Although very effective, labor costs will restrict this option to local areas where other controls may not be feasible, or to a small infested site or program area.

NOTE: Sticky trunk barriers are not recommended for either survey or control purposes, since for the former, the sticky barrier causes problems in removal of the specimen(s) and for the latter, it appears not to be very effective in reducing larval density, since at a top rate of reduction of ≈27-28 percent of larvae per square meter, neither defoliation nor egg mass density is reduced (Thorpe & Ridgway, 1994).

Such banding, however, may be used by individual property owners to help protect their trees by generally preventing primary invasions by newly hatched larvae and secondary invasions by ballooning larvae, dropping larvae from trees, and swarming larvae from adjacent areas. Various products on the market, such as tanglefoot, bug glue, and bug gum will serve this function in combination with duct tape (Raupp, et al., 1987).

(3). Sanitation

Sanitation in nurseries, farms, gardens, and other establishments where hosts are present will be carried out within the core and buffer areas. Sanitation will consist of the following measures to be applied, depending on the circumstances and equipment available.

a. Burning of Debris

When host material is collected, it may be piled into heaps and burned if local ordinances permit. The residue can be disked under or otherwise buried in an approved landfill. Care should be taken not to unduly disturb egg masses, larval nests, or pupal cases, which could result in scattering eggs, larvae, or pupae so that they escape destruction.

b. Animal Food

Some kinds of host material may be used as animal food, with any residue disposed of by burning/burial at an approved landfill.

c. Bagged and Buried

Host material may be collected in suitable containers and transported to an approved landfill. Care should be taken not to unduly disturb egg masses, larval nests or pupal cases, which could result in scattering eggs or pupae so that they escape burial.

d. Immersion

Life stages may also be collected in suitable containers and soaked therein, fully covered with a hot soapy water solution. Larval nests may be torn open. Care should be taken to be sure that all live stages are completely soaked and held long enough to ensure destruction before disposal.

(4). Vehicle/Outdoor Inspection/Cleaning

Vehicles, trucks, wagons, outdoor furniture, containers and other things left outdoors, etc., that are used in host fields, stands, orchards, woods or yards within the regulated area, must be inspected to ensure that accidental movement of egg masses or pupal cases does not occur. Cleaning consists of the removal and destruction of any egg masses, pupal cases, or larvae found.

(5). Host Inspection/Cleaning

In cases of limited infestations, an inspection of hosts and/or nearby nonhosts may turn up suspect egg masses, overwintering larval nests, pupal cases, or larvae. Cleaning the trunks and stems of the pest and cutting off larval nests can do much to reduce the infestation, especially if done in autumn, after harvest, for the following year (Rane, 1912; Borisoglebskaya, 1978; Bertucci, 1984). Disposal must be carefully carried out to prevent any life stages from escaping destruction.

Orientation of Control/Eradication Personnel

All personnel will be adequately trained and utilized initially.

Eradication/ Control Records

As stated under "Recommended Pesticides," records will note the locations, dates, number, and type of treatments. All control records will meet NEPA requirements.

Monitoring

An effective monitoring program will be implemented to aid in the evaluation of program efforts and environmental impact.

1. The application of any of the biological and/or cultural controls will be assessed through the use of appropriate sampling criteria. This will include surveys of the target population to monitor populational changes in response to the release or application of biologicals, parasites, predators and all supplementary methods. It will also measure the possible impact, if any, on non-target endemic organisms.

2. The application of pesticides will be assessed through the use of appropriate monitoring program criteria. The evaluation must effectively address Agency, cooperator, and public concerns. Special techniques for monitoring the effect of insecticides on forest fauna will likely be applicable.

a. Determine the efficacy of the pesticide application against the target pest.

b. Monitor aerial applications, using dye cards to determine:

(1). Droplet size
(2). Droplet distribution
(3). Identification of drift components

(4). Verification of spray block boundaries
(5). Identification of skips

c. Sampling to determine the impact on soil, water, vegetation, and non-target species.

CONTACTS

When a lymantriid program is implemented, its success will depend on the cooperation, assistance, and understanding of many involved groups. The following groups should be continually informed of all operational phases of an emergency program.

1. Agricultural and forestry officials
2. The general public
3. Environmental groups
4. Commercial (grower-marketer interests)
5. Universities
6. State and local law enforcement officials
7. Public health
8. Foreign plant protection groups
9. National, State, and local news media
10. U.S. Fish & Wildlife
11. State natural heritage programs

PATHWAY EVALUATION

Natural Means

In general, the Lymantriidae do not qualify as long range migrants.

Adult Dispersal

However, a few are short-range windborne travelers, most notably males of *Lymantria dispar, Euproctis chrysorrhoea, and Leucoma salicis,* sometimes cover distances within the range of 62-124 mi.(100-200 km) (Ferguson, et al., 1991; Ferguson, 1978). Air masses apparently moved *L. dispar* males and females from Leningrad to Scandinavia (McManus, FS, pers. comm.).

Simple wind dispersal itself may result in infestations 1.2-2.4 mi.(2-4 km) away from the source (Lesko, 1988). Male moths of *Lymantria monacha* were recaptured from 300 yards (280 meters) after release after 24 hours and up to 2.17 mi. (3500 meters) after 24 days (Skuhravy & Zumr, 1978).

Natural spread is somewhat greater if the female is capable of flight; i.e., females of the Asian strain of gypsy moth are capable of flights exceeding 18 mi.(30 km) (Wallner, 1992; Swadener, 1992).

Larval Dispersal

Natural spread by first instar larvae on silken threads, in fact, is generally limited to a few hundred yards (or meters). This can be offset by several conditions: the "sea breeze" effect where larval deposition is concentrated in a band about 6-12 mi. (10-20 km) inland; and the "ridge-and-valley" system, where larval deposition is concentrated in a band just short of the next ridge (Cameron et al., 1978).

The rate of natural spread of *Lymantria dispar* (European gypsy moth) in the United States has been estimated to be about 2-6 mi. (3-10 km) per year before 1966; and 13 mi. (21 km) per year since 1966 (Liebhold, et al., 1992).

Travel and Commerce

Lymantriid females are attracted to light. They normally oviposit on the bark of trees. In today's world, however, they may instead lay eggs or pupate on lamp posts, buildings, or on various items which are often moved by man; including vehicles, ships, and cargo containers.

Among the sites to be considered at risk for any already established pest are recreational areas, especially those with a high volume of traffic. Although all life cycles are subject to being moved, it is the egg stage that is usually the most serious problem.

Wood, bushes, trees, tents, outdoor household articles, trailers, vehicles, and mobile homes are examples of items which may have egg masses or pupae deposited on them. We can also include plant material and/or nursery stock such as rose bushes, tea plants, and conifer trees of any age.

The possible contamination of shipping containers or pallets are of much regulatory concern. This is because they may be infested with larvae/pupae or perhaps females which are attracted to them because they are stored in a lighted area. While there, the females may lay eggs. Ships (or aircraft), especially cargo ships, may be carrying containers, pallets or items within, with lymantriid life stages aboard.

Artificial movement, world-wide, has occurred numerous times for many lymantriid species.

As a result, lymantriids may be found at ports of entry, along waterways and/or roads, at camping sites, in places with leisure activities, and in backyards; and on vehicles, cargo, logs, containers or host plant material.

ADDENDUM 1

Definitions

Aerial Treatment—Applying an insecticide by aircraft over a treatment area.

Array Sequence—The trapping pattern (array) beginning with the core area and continuing outward through the buffer area.

Augmentation—The intentional addition of natural enemies by mass release in areas where these enemies are absent, occur too late in the season or pest life cycle, or are in ineffective numbers.

Biological Control—The development and use of natural means of control through parasites, predators, pathogens and biological tactics to suppress a pest population density below a level that would not occur in their absence, either for a given period of time, or permanently.

Biological Tactics—The use of any natural or derived product or technique utilizing biological applications such as gene transfer, genetic manipulation, pheromone attractants, host substitution or other biological tactics to suppress a pest population density below a level that would not occur in their absence, either for a given period of time, or permanently.

Biometric Survey—A survey on an organism which combines valid statistical procedures with known biological information. For the Lymantriidae, APHIS uses statistics and biological information on ecology and life cycle characteristics to develop surveys to determine the presence (or absence) of a moth and/or damage caused by the moth.

Blacklight Trap—A trap with a special bulb radiating light in ultraviolet wavelengths, which can be attractive to moths.

Buffer Area—The area extending beyond the boundary of the core area--generally the 3 to 19-mi buffer within the regulated area.

Chemical Integration—The direct application of selected chemicals to the host which are nontoxic or relatively nontoxic to selected parasites or predators.

Classical Biological Control—The introduction of exotic natural enemies from the region of origin to provide a permanent, self-sustaining suppression of a pest population density below a level that would not occur in their absence.

Commercial Production Area—An area where host material is grown for commercial distribution.

Confirmed Detection—A positive identification by a recognized expert of a submitted life form (specimen) as an exotic lymantriid.

Core Area—An area encompassing a confirmed exotic lymantriid detection where all elements of a detection, survey, regulatory, and control program are carried out.

Cross Transect Survey—A survey designed to find the infestation in the shortest possible time. The survey is basically strung out along the two lines of an axis, and run through the most likely host areas. It may eventually be replaced by a survey based on the grid system for more thorough coverage.

Cultural Control—The intentional use of simple practices or mechanical measures which may be available to control a pest population.

Day Degrees—An accumulation of heat units above a developmental threshold.

Delimiting Survey—A survey to determine the density and extent of the infestation in an area where an exotic lymantriid has been detected.

Detection—The collection of any life stage of an exotic lymantriid.

Detection Survey—An activity conducted in a susceptible area not known to be infested with exotic lymantriids.

Developmental Threshold—The minimum (or maximum) temperature below (or above) which physiological development stops (peaks).

Enablement—To enhance the ability of predators and/or parasites to attack a host with greater efficiency or to be more tolerant of insecticides or other control practices through selective breeding and/or gene manipulation.

Epicenter/Focal Point—The initial site of an infestation.

Exotic Lymantriid—A species of lymantriid not native to or non-indigenous in an area.

Fumigation—The application of an approved fumigant (e.g., methyl bromide) as a treatment.

Generation—The period of time for the pest to complete all stages of a life cycle.

Ground Spray—Using ground spray equipment to apply an insecticide to host vegetation or other target locations in an infested area.

Host—A plant species that is a food resource of an exotic lymantriid.

Host Collection/Holding—The collection and holding of host material to determine the extent and nature of the infestation.

Infestation—Any evidence of a reproductive population.

Infested Area—An area where a reproducing population exists.

Inoculative Augmentation—Flooding a chosen area with large numbers of one or more natural enemies at the time a pest occurs or is expected to occur in an area, with the intention of having established populations of these enemies through subsequent generations for pest control.

Inundative Augmentation—Flooding a chosen area with large numbers of one or more natural enemies to exert rapid control of a pest in the present generation in order to prevent or decrease possible damaging host losses.

Lymantriidae—The scientific name for the family of tussock moths. Lymantriid is a vernacular version. This family has been or is still known in other countries by the name Liparidae. Specific genera and species are given in the text.

Monitoring/Evaluation Survey—Using interdependent visual and trapping surveys in an area where treatment has been applied, to evaluate the effectiveness of the application.

Parasite/Predator Conservation—The conservation of natural enemies through integrated procedures, highly selective predator/parasite friendly insecticides or techniques, biological insecticides, or cultural practices favoring parasites/predators.

PPQ-APHIS-USDA—Plant Protection and Quarantine, Animal and Plant Health Inspection Service, United States Department of Agriculture.

Regulated Area—An area that extends at least 4 to 20 miles in any direction from the epicenter of an infestation.

Regulated Articles—Articles which present a high risk for the artificial movement of a regulated pest (as listed in the CFR or EAN).

Regulatory Survey—Surveys conducted around establishments where regulated articles are kept, sold, handled, processed, or moved.

Sex Pheromone—A pheromone which will attract the male (or female) of a given lymantriid.

Trap Array—The trapping pattern in a designated 1-mi^2 area.

Trap Survey—Determining the presence or absence or relative density of a pest by the use of traps placed in a predetermined pattern and serviced on a given schedule.

Visual Survey—Examining areas for eggs, larvae, cocoons, and adults, either outside in the field or in regulated establishments.

ADDENDUM 2

Safety

Personal and public safety must be a prime consideration at all times. Safety practices should be stressed in preprogram planning and through the duration of actual program operations. Supervisors must enforce on-the-job safety procedures.

The larvae of the Lymantriidae possess poisonous hairs on the body. These hairs, about 2-3 mm in length, may cause dermatitis similar to poison ivy. The rash can be severe and persist for weeks in sensitive individuals. The rash is caused by both a chemical reaction to the toxin in the hairs and a physical irritation as the barbed hairs become embedded in the skin.

The hairs easily break off from the larvae or from the cast larval skins left behind after molting. This material can easily become airborne. Respiratory distress from inhaling the hairs can be serious.

The larval hairs of some species are more poisonous than those of other species. For example, those of the browntail moth (*Euproctis chrysorrhoea*) are said to be 20 times as toxic as those of the gypsy moth (*Lymantria dispar*).

For program lymantriids with highly toxic hairs, the following precautions may need to be observed. These precautions are paraphrased from those followed by the Maine Forest Service in dealing with the browntail moth and, depending on the lymantriid species involved, may or may not require additional precautions.

The following precautions are recommended for anyone living in or visiting browntail moth infested areas during spring or summer:

- Avoid areas where trees or shrubs are lacking leaves, for this indicates a heavy infestation of caterpillars.
- Take a cool shower and change clothes after any activity that might involve contact with browntail moth hairs.
- Dry laundry inside during June and July (early summer) to avoid hairs becoming impregnated in the clothing.
- Wear respirator, goggles, and coveralls tightly closed at the neck, wrists, and ankles when:

  —Entering infested areas on windy days.
  —Performing activities that would stir up caterpillar hairs, such as:

- mowing
- raking
- weed-wacking
- removing pupal webbing from eaves, boats, and other objects

- In addition, work on damp days or wet down material with a hose, as moisture helps to keep hairs from becoming airborne.

- Use extreme caution, when handling contaminated or suspect material, even if the material has been there for a number of years, as the toxin is extremely stable.

- Consult a physician if a severe reaction to the presence of the lymantriid is suspected.

In addition to the above, all safety precautions given on label directions, OSHA and EPA documents must be followed.

ADDENDUM 3

Hosts:

INSECT:	HOST	
	Scientific Name	Common Name
Arctornis alba	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Camellia sasanqua	Oil-tea camellia (Chung-Ling, 1992)
	Corylus sp.	Hazel (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Arctornis gelasphora	*Quercus* spp.	Oak (Chung-Ling, 1992)
	Castanea spp.	Chestnut (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
	Vernicia fordii	Tung tree (Chung-Ling, 1992)
Arctornis 1-nigrum	*Corylus* spp.	Hazel (Chung-Ling, 1992)
	Malus spp.	Apple (Chung-Ling, 1992)
	Populus spp.	Poplar (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Salix spp.	Willow (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Arctornis xanthochila	*Quercus* spp.	Oak (Chung-Ling, 1992)
Aroa substrigosa	Poaceae	Bamboo (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
Calliteara cerigoides	*Shorea javanica*	-- (Nesser, et al., 1992)
	Hopea odorata	Thingwa (Nesser, et al., 1992)
Calliteara (= Elkneria = Dasychira) pudibunda		(Klimetzek, 1984)
		Deciduous trees
		Shrubs
		Fruit trees

INSECT:	HOST	
	Scientific Name	Common Name
Calliteara (= Elkneria = Dasychira) pudibunda	*Alnus* spp.	Alder
	Betula spp.	Birch
	Carpinus spp.	Hornbeam
	Corylus spp.	Hazel
	Fagus spp.	Beech
	Fagus sylvatica	European beech (Nilsson, 1978)
	Humulus lupulus	Hops
	Juglans spp.	Walnut
	Malus spp.	Apple (Carter, 1984)
	Populus spp.	Poplars
	Prunus armeniaca	Apricot (Carter, 1984)
	Pyrus spp.	Pear (Carter, 1984)
	Quercus spp.	Oak
	Rubus spp.	Rose
	Salix spp.	Willow
	Tilia spp.	Lime
	Tilia spp.	Linden (Schmidt, 1988)
	Ulmus spp.	Elm
NOTE: This species occurs on many other wild and cultivated fruits (Gomez-Bustillo, et al., 1980). The hosts above are given by the same authors. Carter, 1984, states that this lymantriid is regarded as a forest pest of beech trees in Central and Northern Europe.		
Cifuna eurydice	*Vitis vinifera*	Grape (Chung-Ling, 1992)
	Malus pumila	Apple (Chung-Ling, 1992)
Cifuna jankowskii	*Vitis vinifera*	Grape (Chung-Ling, 1992)
	Malus domestica	Apple (Chung-Ling, 1992)
	Actinidia deliciosa (= chinensis)	Kiwi fruit (Chung-Ling, 1992)
NOTE: Hosts as in Chung-Ling, 1992.		
Dasychira abietis		Forest trees (Anderson & Kaya, 1976)

INSECT:	HOST	
	Scientific Name	Common Name
Dasychira angulata	*Quercus* spp.	Oak (Chung-Ling, 1992)
Dasychira argentata	*Chamaecyparis obtusa*	Japanese cypress (Shibata, 1981)
	Cryptomeria japonica	Japanese cedar (Shibata, 1981)
Dasychira aurifera	*Quercus variabilis*	Oriental oak (Chung-Ling, 1992)
Dasychira axutha	*Cunninghamia lanceolata*	Chinese fir (Chung-Ling, 1992)
	Pinus massoniana	Masson pine (Chung-Ling, 1992)
	Pinus spp.	Pines (Chen & Wu, 1981)
	Taxodium sp.	Swamp cypress, a (Chung-Ling, 1992)
Dasychira baibarana	*Camellia sinensis*	Tea (Chung-Ling, 1992)
Dasychira basalis	*Allium* spp.	Onion
	Cajanus cajan	Pigeon pea
	Coffea arabica	Coffee
	Gossypium spp.	Cotton
	Manihot esculenta	Cassava
NOTE: Species listed are by Holden, 1998.		
Dasychira basiflava	*Carya* spp.	Hickory
	Cornus florida	Flowering dogwood
	Fagus spp.	Beech
	Quercus alba	White oak
	Ulmus rubra	Slippery elm
NOTE: Species listed are by Baker, 1972.		
Dasychira chekiangensis	*Populus* spp.	Poplar (Chung-Ling, 1992)
	Salix spp.	Willow (Chung-Ling, 1992)
	Ulmus spp.	Oak (Chung-Ling, 1992)
Dasychira conjuncta	*Ulmus* spp.	Oak (Chung-Ling, 1992)
	Populus spp.	Poplar (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Dasychira conjuncta	*Tilia* spp.	Linden (Chung-Ling, 1992)
	Acer spp.	Maple (Chung-Ling, 1992)
	Pinus massoniana	Masson pine (Chung-Ling, 1992)
Dasychira dalbergiae	*Malus pumila*	Apple (Chander & Dogra, 1983)
Dasychira fortunata	*Pinus canariensis*	Canary Island pine (Bacallado, 1981)
		Other plants (Bacallado, 1981)
Dasychira glaucinoptera	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Citrus sinensis	Sweet orange (Chung-Ling, 1992)
Dasychira grotei	*Citrus sinensis*	Orange (Chung-Ling, 1992)
	Theobroma cacao	Cocoa (Chung-Ling, 1992)
	Malus domestica	Apple (Chander & Dogra, 1983)
		Ornamental plants (Wu & Huang, 1986)
Dasychira horsfieldi	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Citrus aurantium	Sour orange (Chung-Ling, 1992)
	Malus sp.	Apple (Gupta, et al., 1989)
Dasychira inclusa	*Citrus* spp.	Citrus
	Coffea arabica	Coffee
	Ficus spp.	Ficus
	Theobroma cacao	Cocoa
	Leguminosae	Legumes
NOTE: Species listed are by Holden, 1998.		
Dasychira locuples	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Diospyros spp.	Persimmon (Chung-Ling, 1992)
	Glycine max	Soybean (Zhu, et al., 1980)
	Salix spp.	Willow (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
	Vernicia fordii	Tung tree (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Dasychira locuples	Leguminosae	Legumes (Chung-Ling, 1992)
Dasychira lunulata	*Quercus* spp.	Oak (Chung-Ling, 1992)
	Castanea spp.	Chestnut (Chung-Ling, 1992)
Dasychira manto	*Pinus* spp.	Pines (Holden, 1998)
Dasychira mendosa	*Bauhinia purpurea*	Purple bauhinia (Das, 1990)
	Bombax ceiba	Red silk-cotton tree (Matthew, 1978)
	Cajanus cajan	Pigeon pea (Singh & Rao, 1986)
	Camellia sinensis	Tea (Koshiya & Bharodia, 1976)
	Cinnamomum zeylanicum	Cinnamon (Rajapakse & Kulasekera, 1982)
	Citrus spp.	Citrus (Nagalingam & Savithri, 1980)
	Cocos nucifera	Coconut (Raghunath & Subramanyam, 1981)
	Corchorus capsularis	Jute, white (Zaman & Karimullah, 1987)
	Corchorus olitorius	Jute, tossa (Zaman & Karimullah, 1987)
	Crossandra infundibuliformis	Firecracker flower (Subba-Rao, et al., 1974a)
	Lablab purpureus	Hyacinth bean (Ramzan, et al., 1988)
	Elaeis guineensis	Oil palm (Dhileepan, 1991)
	Eucalyptus spp.	Gum Trees (Holden, 1998)
	Gliricidia sepium	Nicaraguan Cocoa-shade (Subba-Rao, et al., 1974a)
	Hibiscus cannabinus	Kenas (Zaman & Karimullah, 1987)
	Litchi chinensis	Litchi (Holden, 1998)
	Macadamia spp.	Macadamia (Ironsides, 1980)
	Mangifera indica	Mango (Zaman & Maiti, 1994)
	Flemingia macrophylla	Souphlong (Mehra & Sah, 1974)

INSECT:	HOST	
	Scientific Name	Common Name
Dasychira mendosa	*Morus* spp.	Mulberry (Koshiya & Bharodia, 1986)
	Parthenium argentatum	Guayule (Mathavan, et al., 1984)
	Persea americana	Avocado (Holden, 1998)
	Populus spp.	Poplar (Joshi, et al., 1984)
	Psidium guajava	Guava (Sandhu, et al., 1979)
	Pyrus communis	Pear (Sandhu, et al., 1979)
	Quercus acutissima	Sawthorn Oak (Singh & Prasad, 1990)
	Ricinus communis	Castor (Koshiya & Bharodia, 1976)
	Schleichera oleosa	Ceylon oak (Mehra & Sah, 1974)
	Sesbania bispinosa	Dhaincha (Das, 1990)
	Sesbania speciosa	-- (Subba-Rao, et al., 1974a)
	Plectranthus rotundifolius	Hausa potato (Palaniswani & Pillai, 1981)
	Terminalia arjuna	Arjun (Reddy, et al., 1988)
	Terminalia bellerica	Myrobalan (Reddy, et al., 1988)
	Terminalia tomentosa	-- (Reddy, et al., 1988)
	Ziziphus mauritiana	Indian jujube (Mehra & Sah, 1974)
	Ziziphus xylopyrus	Ghont (Mehra & Sah, 1974)
Dasychira pennatula	*Saccharum officinarum*	Sugarcane
	Oryza spp.	Rice
	Zea mays	Corn
	Juniperus spp.	Juniper
NOTE: Hosts from Holden, 1998.		
Dasychira plagiata	*Abies blasamea*	Balsam fir (Holden, 1998)
	Abies spp.	Firs (Baker, 1972)
	Picea glauca	White spruce (Holden, 1998)
	Picea spp.	Spruces (Baker, 1972)
	Pinus banksiana	Jack pine (Baker, 1972)

INSECT:	HOST	
	Scientific Name	Common Name
Dasychira plagiata	*Pinus resinosa*	Red pine (Baker, 1972)
	Pinus strobus	Eastern white pine (Baker, 1972)
NOTE: Jack pine is especially favored. (Baker, 1972)		
Dasychira securis		Kharif cereals (See Kundu, 1983)
Dicallomera fascelina		Deciduous trees (Gomez-Bustillo, et al., 1980)
		Shrubs (Gomez-Bustillo, et al., 1980)
		Fruit trees (Gomez-Bustillo, et al., 1980)
Euproctis aethiopica		Cereals (Walkers, 1994)
Euproctis bipunctapex	*Camellia* spp.	Camellia (Wang, 1981)
	Diospyros spp.	Persimmon (Chung-Ling, 1992)
	Liquidambar styraciflua	Sweet gum (Chung-Ling, 1992)
	Morus spp.	Mulberry (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Sapium sebiferum	Chinese tallow tree (Chung-Ling, 1992)
	Thea sinensis	Tea (Wang, 1981)
		(Lee, et al., 1991)
Euproctis chrysorrhoea		Fruit trees (Sterling, 1983)
		Shrubs & Hedges (Sterling, 1983)
	Arbutus unedo	Strawberry tree (Scortichini, 1986)
	Corylus spp.	Hazelnut (Bertucci, 1984)
	Crataegus sp.	Hawthorn (Kelly, et al., 1988a)
	Forsythia spp.	Forsythia (Carter, 1984)
	Fragaria spp.	Strawberry (Carter, 1984)
	Hippophae rhamnoides	Sea buckthorn (Kniest & Hoffman, 1984)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis chrysorrhoea	*Juglans* spp.	Walnut (Carter, 1984)
	Malus domestica	Apple (Bertucci, 1984)
	Malus spp.	Apple (Kneifl, 1977)
	Morus spp.	Mulberry (Holden, 1998)
	Populus spp.	Poplars (Sliwa & Swiezynska)
	Prunus armeniaca	Apricot (Carter, 1984)
	Prunus avium	Sweet cherry (Bertucci, 1984)
	Prunus domestica	Plum, a (Bertucci, 1984)
	Prunus maritima	Beach plum (Leonhardt, et al., 1991)
	Prunus persica	Peach (Carter, 1984)
	Prunus spinosa	Blackthorn, sloe (Holden, 1998)
	Pyrus communis	Pear (Bertucci, 1984)
	Quercus spp.	Oak (Sliwa & Swiezynska, 1978)
	Quercus robur	English oak (Lesko, 1984)
	Ribes spp.	Gooseberry (Carter, 1984)
	Ribes rubrum	Redcurrent (Carter, 1984)
	Rosa spp.	Rose (Carter, 1984)
	Rubus spp.	Bushes (Speight, et al., 1992)
	Rubus idaeus	Raspberry (Carter, 1984)
	Rubus fruticosus	Blackberry, wild european (Sterling, et al., 1988)
	Salix spp.	Willow (Carter, 1984)
	Ulmus spp.	Elms (Munoz & Ruperez, 1980)
NOTE: Hosts also noted by Baker, 1972, under the name *Nygmia phaerorroea.* During the 1970-80's, known almost entirely in old abandoned orchards following a sharp decline, but has since resurged in the 1990's and again in a problem in Maine and Cape Cod.		
Euproctis cryptosticta	*Ricinus communis*	Castor bean (Chung-Ling, 1992)
	Smilax chinal	China root green brier (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis dewitzi		Cereals (Walker, 1994)
Euproctis digramma	*Pyrus communis*	Pear (Chung-Ling, 1992)
Euproctis diploxutha	*Castanea mollissima*	Chestnut (Chung-Ling, 1992)
	Eucalyptus spp.	Eucalyptus (Chung-Ling, 1992)
	Prunus spp.	Plum (Chung-Ling, 1992)
	Pyrus communis	Pear (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Rosa spp.	Rose (Chung-Ling, 1992)
Euproctis edwardsi	*Viscum album*	Mistletoe, european (Thompson, 1984)
Euproctis fasciata	*Manihot esculenta*	Cassava (Apeji, 1980)
	Apios americana	Peanut (Apeji, 1980)
	Prunus armeniaca	Apricot (Apeji, 1980)
NOTE: There are 21 listed food plants and probably many more unlisted (Sevastopulo, 1981).		
Euproctis flava	*Cunninghamia lanceolata*	Chinese fir (Chung-Ling, 1992)
	Camellia sinensis	Tea (Chung-Ling, 1992)
	Diospyros spp.	Persimmon (Chung-Ling, 1992)
	Populus spp.	Poplar (Chung-Ling, 1992)
	Pinus spp.	Pine (Chung-Ling, 1992)
	Sassafras albidum	Sassafras (Chung-Ling, 1992)
	Taxodium spp.	Cypress (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
	Vernicia fordii	Tung tree (Chung-Ling, 1992)
		(Tsia & Ding, 1982)
		(Kawamoto, et al., 1977)
Euproctis flavinata	*Malus* spp.	Apple (Chung-Ling, 1992)
	Pyrus communis	Pear (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis favinata	*Citrus sinensis*	Orange, sweet (Chung-Ling, 1992)
Euproctis flavotriangulata	*Juglans* spp.	Walnut (Chung-Ling, 1992)
Euproctis fraterna	*Abelmoschus esculentus*	Okra (Manoharan, et al., 1982)
	Annona squamosa	Custard apple (Verma, et al., 1989)
	Cinnamomum zeylanicum	Cinnamon (Rajapakse & Kulasekera, 1982)
	Ficus racemosa	Crattock (Verma, et al., 1989)
	Gossypium spp.	Cotton (Holden, 1998)
	Hibiscus sabdariffa	Roselle (Manoharan, et al., 1982)
	Ricinus communis	Castor (Manoharan, et al., 1982)
	Malus domestica	Apple (Thakur, et al., 1974)
	Mangifera indica	Mango (Manoharan, et al., 1982)
	Phyllanthus emblica	Emblic (Verma, et al., 1989)
	Prunus domestica	Plum (Batra, et al., 1979)
	Psidium guajava	Guava (Ram & Pathak, 1987)
	Punica granatum	Pomegranate (Holden, 1998)
	Pyrus communis	Pear (Chung-Ling, 1992)
	Rosa sp.	Rose (Chung-Ling, 1992)
	Zizyphus mauritiana	Ber (Shah, et al., 1990)
	Zizyphus xylopyrus	Thont (Sah, et al., 1972)
	Leguminosae	Pulse Crops (Holden, 1998)
Euproctis icilia	*Ricinus communis*	Castor (Khan & Srivastava, 1990)
Euproctis kargalika	*Acer platanoides turkestanicum*	Turkistan maple
	Atraphaxis pyrifolia	Pear-leaved orach
	Crataegus turcestanica	Turkistan hawthorn
	Malus sylvestris	Wild crabapple
	Prunus mahaleb	Mahaleb cherry

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis kargalika	*Pyrus communis*	Pear
	Rosa sp.	Rose, a
NOTE: Hosts from Romanenko, 1981.		
Euproctis latifascia	*Vernicia fordii*	Tung tree (Chung-Ling, 1992)
	Zea mays	Corn (Chung-Ling, 1992)
Euproctis lunata	*Acacia nilotica tomentosa*	Gum arabia tree (Gurdip, et al., 1981b)
	Anacardium occidentale	Cashew (Jena, et al., 1984)
	Ricinus communis	Castor bean (Srivastava, et al., 1983)
	Morus alba	White mulberry (Butani, 1978)
	Morus nigra	Black mulberry (Butani, 1978)
	Pennisetum glaucum	Pearl millet (Dabi, et al., 1980)
	Quercus spp.	Oak (Chao, 1984)
	Prunus domestica	Plum, a (Gurdip, et al., 1981b)
	Ziziphus jujuba	Jujube (Gurdip, et al., 1981b)
	Ziziphus mauritiana	Ber (Shah, et al., 1990)
	Rosa spp.	Rose (Gurdip, et al., 1981b)
Euproctis lutfacia	*Elettaria cardamomum*	Cardamom (Kumaresan, et al., 1987)
Euproctis melania	*Quercus* spp.	Oak (Awadallah, et al., 1979)
	Malus domestica	Apple (El-Bahrawi, et al., 1979)
	Pyrus communis	Pear (El-Bahrawi, et al., 1979)
	Prunus spp.	(Abai, 1976)
Euproctis mesostiba	*Castanea mollissima*	Chestnut, Chinese (Chung-Ling, 1992)
Euproctis montis	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Citus sinensis	Orange, sweet (Chung-Ling, 1992)
	Lycopersicon esculentum	Tomato (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis montis	*Morus* spp.	Mulberry (Chung-Ling, 1992)
	Prunus persica	Peach (Chung-Ling, 1992)
	Pyrus communis	Pear (Chung-Ling, 1992)
	Salix spp.	Willow (Chung-Ling, 1992)
	Solanum tuberosum	Potato (Chung-Ling, 1992)
	Vitis spp.	Grape (Chung-Ling, 1992)
Euproctis niphonisi	*Betula papyrifera*	Paper birch (Chung-Ling, 1992)
	Castanea mollissima	Chinese chestnut (Chung-Ling, 1992)
	Corylus colurna	Turkish hazel (Chung-Ling, 1992)
	Populus spp.	Red poplar (Chung-Ling, 1992)
	Rosa spp.	Rose (Chung-Ling, 1992)
Euproctis producta	*Ricinus communis*	Castor (Hill, 1975)
Euproctis pseudoconspersa	*Camellia japonica*	Japanese camellia (Wakamura, et al., 1994)
	Camellia sasanqua	Sasanqua camellia (Wakamura, et al., 1994)
	Diospyros spp.	Persimmon (Chung-Ling, 1992)
	Sapium sebiferum	Chinese tallow tree (Chung-Ling, 1992)
	Camellia sinensis	Tea (Wang, 1981)
	Vernicia spp.	Tung tree (Chung-Ling, 1992)
	Theaceae (in general)	(Wakamura, et al., 1994)
		Forest trees (Fan, et al., 1988)
Euproctis scintillans	*Acer* spp.	Maple (Chung-Ling, 1992)
	Camellia sinensis	Tea (Chung-Ling, 1992)
	Citrus sinensis	Orange, sweet (Chung-Ling, 1992)
	Dimocarpus longan	Longan (Chung-Ling, 1992)
	Gossypium hirsutum	Cotton (Chung-Ling, 1992)
	Malus domestica	Apple (Chander & Dogra, 1983)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis scintillans	*Psophocarpus tetragonolobus*	Winged bean (Shanthichandra, et al., 1990)
	Pyrus communis	Pear (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Ricinus communis	Castor (Koshiya, et al., 1977)
	Sesbania cannabina	Dhaincha (Subba-Rao, et al., 1974)
	Vigna mungo	Gram, black (Subba-Rao, et al., 1974)
	Vigna radiata	Gram, green (Subba-Rao, et al., 1974)
	Zea mays	Corn (Chung-Ling, 1992)
	Several Genera	Bean, field (Subba-Rao, et al., 1974)
Euproctis similis	*Acer* spp.	Maple (CIE, 1978)
	Betula spp.	Birch (Carter, 1984)
	Castanea sp.	Chestnut (Togashi, 1977)
	Citrus spp.	Citrus (CIE, 1978)
	Corylus spp.	Hazel (Carter, 1984)
	Cotoneaster spp.	Ornamental, an (Carter, 1984)
	Crataegus monogyna	Hawthorn, a (Port & Thompson, 1980)
	Fagus spp.	Beeches (Carter, 1984)
	Humulus lupulus	Hops (Carter, 1984)
	Malus spp.	Apple (Borisoglebskaya, 1978)
	Morus sp.	Mulberry (Chu, et al., 1975)
	Quercus spp.	Oak (CIE, 1978)
	Populus spp.	Poplar (CIE, 1978)
	Prunus armeniaca	Apricot (Stus', 1979)
	Prunus dulcis	Almond (Stus', 1979)
	Prunus spp.	Ornamentals & stone fruits (CIE, 1978)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis similis	*Prunus* spp.	Plum (Carter, 1984)
	Prunus spp.	Cherry (Carter, 1984)
	Prunus spp.	Ornamental cherry (Carter, 1984)
	Pyrus communis	Pear (Borisoglebskaya, 1978)
	Ribes spp.	Gooseberry (Carter, 1984)
	Rosa spp.	Rose (Carter, 1984)
	Rubus loganobaccus	Loganberry (Carter, 1984)
	Rubus spp.	Raspberry (Carter, 19840
	Rubus spp.	Blackberry (Carter, 1984)
	Salix spp.	Willow (Carter, 1984)
	Tilia spp.	Lime (CIE, 1979)
	Ulmus spp.	Elm (Chung-Ling, 1992)
	Viburnum spp.	(Carter, 1984)
		Forest trees (Wang, 1982)
		Fruit trees (Stus', 1980)
		Ornamental plants, bushes (Strand & Sylvester, 1981)
NOTE: Seems to cause only minor damage to fruit trees in Europe, but not considered to be an economic pest (Carter, 1984).		
Euproctis staudingeri	*Rosa* spp.	Rose (Chung-Ling, 1992)
	Ruta spp.	Rue (Chung-Ling, 1992)
Duproctis straminea	*Juglans* spp.	Walnut (Chung-Ling, 1992)
	Populus spp.	Poplar (Chung-Ling, 1992)
Euproctis subnotata	*Anacardium occidentale*	Cashew (Jena, et al., 1984)
	Cajanus cajan	Pigeon pea (Lateef & Reddy, 1984)
	Camellia sinensis	Tea (Das & Goswami, 1977)
	Hevea brasiliensis	Rubber (Sujan, et al., 1985)
	Sorghum bicolor	Sorghum (Hardas, et al., 1978)

INSECT:	HOST	
	Scientific Name	Common Name
Euproctis subnotata	*Theobroma cacao*	Cocoa (Radha & Rawther, 1976)
Euproctis taiwana	*Gladiolus italicus*	Corn flag (Wang, C.L., 1982)
	Glycine max	Soybean (Talekar, et al., 1988a)
	Vigna radiata	Mungbean (Talekar, et al., 1988a)
	Vitis vinifera	Grape (Chang, 1988)
Euproctis terminalis	*Acacia karroo*	Karroo thorn (Donaldson, 1991)
	Pinus patula	Mexican yellow pine (Geertsema, et al., 1978)
	Pinus spp.	Pines (Holden, 1988)
Euproctis varian	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Citrus sinensis	Orange (Chung-Ling, 1992)
	Morus spp.	Mulberry (Chung-Ling, 1992)
	Pinus massoniana	Masson pine (Chung-Ling, 1992)
	Taxodium spp.	Cypress (Chung-Ling, 1992)
Euproctis virguncula	*Triticum aestivum*	Wheat (Sandhu & Deol, 1975)
	Zea mays	Corn (Sajjan, et al., 1986)
Euproctis vitellina	*Malus domestica*	Apple (Chander & Dogra, 1983)
Euproctis xanthomelaena		Cereals (Walker, 1994)
Euproctis xanthorrhoea	*Corchorus capsularis*	Jute, white (Zaman & Karimullah, 1987)
	Corchorus olitorius	Jute, toss (Zaman & Karimullah, 1987)
	Helianthus annuus	Sunflower (Sethi & Garg, 1983)
	Hibiscus cannabinus	Kenaf (Zaman & Karimullah, 1987)
	Oryza sativa	Rice (Pati & Mathur, 1986)
	Phaseolus lunatus	Lima beans (Bhatnagar & Agarwal, 1985)
Gynaephora aureata	Cyperaceae	Sedges, forage (Chou & Ying, 1979)

INSECT:	HOST	
	Scientific Name	Common Name
Gynaephora aureata	Gramineae	Grasses, forage (Chou & Ying, 1979)
Gynaephora minora	Cyperaceae	Sedges, forage (Chou & Ying, 1979)
	Gramineae	Grasses, forage (Chou & Ying, 1979)
Gynaephora ginghaiensis	Cyperaceae	Sedges, forage (Chou & Ying, 1979)
	Gramineae	Grasses, forage (Chou & Ying, 1979)
Gynaephora ruoergensis	Cyperaceae	Sedges, forage (Chou & Ying, 1979)
	Gramineae	Grasses, forage (Chou & Ying, 1979)
Gynaephora selenitica	*Andromeda polifolia*	Bog-rosemary, a
	Betula pubescens	Birch, european
	Betula pendula	Birch, silver
	Betula spp.	Birches
	Calluna vulgaris	Heather
	Deschampsia caespitosa	Tufted hair grass
	Lathyrus pratensis	Everlasting pea
	Lathyrus sylvestris	Narrow-leaved everlasting pea
	Luzula sp.	Rushes
	Populus tremula	Aspen, european quaking
	Potentilla erecta	Tormentil
	Quercus rubra	Red oak, American
	Rubus idaeus	Red raspberry
	Salix aurita	Willow, a
	Salix caprea	Pussy willow
	Salix phylicifolia	Willow, a
	Trifolium pratense	Red clover

INSECT:	HOST	
	Scientific Name	Common Name
Gynaephora selenitica	*Trifolium* sp.	Clovers
	Vaccinium myrtillus	Bilberry
	Vaccinium uliginosum	Alpine blueberry
	Vicia cracca	Tufted vetch
	Leguminosae	Legumes
NOTE: All hosts from Holden, 1998.		
Ivela auripes	*Cornus macrophylla*	Dogwood, himalayan (Togashi & Kodani, 1990)
	Cornus controversa	Dogwood, giant (Togashi & Kodani, 1990)
Ivela ochropoda		Forest trees (Yan, et al., 1990)
Laelia coenosa	*Oryza sativa*	Rice (Chung-Ling, 1992)
	Phragmites australis	Reed, common (Li, 1987a)
	Populus spp.	Poplar (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
	Cut & dried grass, clover, alfalfa	Hay (Chung-Ling, 1992)
****Hosts not listed. (See--Li, 1987)		
Laelia fasciata	*Oryza sativa*	Rice (Pati & Mathur, 1986)
Laelia monoscola	*Populus* spp.	Poplar (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Leucoma candida		Forest trees (Wang, 1982)
	Populus spp.	Poplars (Ueda, et al., 1981)
	Salix spp.	Willow (Chung-Ling, 1992)
Leucoma salicis	*Amelanchier* spp.	Saskatoon (Humphreys, 1984)
	Malus spp.	Crabapple (Humphreys, 1984)
	Populus alba	White poplar (Wagner & Leonard, 1979)
Leucoma salicis	*Populus balsamifera*	Balsam poplar (Wagner & Leonard, 1979)

INSECT:	HOST	
	Scientific Name	Common Name
Leucoma salicis	*Populus* x *canescens*	Poplar, eastern (Cobanoglu, 1992)
	Populus deltoides	Plains cottonwood (Wagner & Leonard, 1979)
	Populus grandidentata	Bigtooth aspen (Wagner & Leonard, 1980)
	Populus nigra 'Italica'	Lombardy poplar (Wagner & Leonard, 1979)
	Populus nigrasallow	Poplar, a (Holden, 1998)
	Populus simonii	Simon poplar (Wagner & Leonard, 1979)
	Populus tremula	Aspen, european (Nikiforov, 1979)
		Aspen, quaking
	Populus tremuloides	Aspen, quaking (Holden, 1998)
	Populus trichocarpa	Black cottonwood (Holden, 1998)
	Populus spp.	Poplars (Baker, 1972)
	Quercus spp.	Oaks (Humphreys, 1984)
	Salix caprea	Pussy willow (Holden, 1998)
	Salix caspica	Caspian willow (Marikovskiil, 1977)
	Salix cinerea	Gray willow (Holden, 1998)
	Salix fragilis	Brittle willow (Holden, 1998)
	Salix myrsinifolia	Willow, whortle (Holden, 1998)
	Salix phylicifolia	Willow, a (Holden, 1998)
	Salix starkeana	Willow, a (Holden, 1998)
	Salix spp.	Willows (Baker, 1972)
Leucoma sericea	*Parrotiopsis jaquemontiana*	Himalayan ironwood tree (Bhat, 1989)
Leucoma wiltshirei	*Quercus* spp.	Oaks (Adeli, 1980)
	Quercus persica	(Alizadeh, 1977)
Lymantria ampla	*Anacardium occidentale*	Cashew (Ramaseshiah & Bali, 1987)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria ampla	*Casuarina equisetifolia*	Horsetail casuarina (Ramaseshiah & Bali, 1987)
	Ficus religiosa	Peepul tree (Ramaseshiah & Bali, 1987)
	Gossypium spp.	Cotton (Pramanik & Basu, 1975)
	Terminalia catappa	Tropical-almond (Holden, 1998)
	Theobroma cacao	Cocoa (Ramaseshiah & Bali, 1987)
Lymantria concolor	*Malus pumila*	Apple (Chander & Dogra, 1983)
	Prunus domestica	Plum, a gage (Bhardwaj, 1987)
	Prunus persica	Peach (Bhardwaj, 1987)
	Quercus incana	Bluejack oak (Beeson & Chatterjee, 1935)
Lymantria dispar		Forest trees (Anderson & Kaya, 1972)
		Polyphagous/on broadleafed trees (Carter, 1984)
	Quercus spp.	Preferred (Carter, 1984)
	Quercus spp.	Oaks
	Betula populifolia	Gray birch
	Populus spp.	Poplar
		Other
		Hardwoods (most species)
	Taxodium distichum	Baldcypress (Wanner, et al., 1995)
		Fruit & nut trees (Miller, et al., 1987)
Suitable: permitting normal development, high survival		
	Malus spp.	Apple
	Prunus armeniaca	Apricot
	Vaccinium spp.	Blueberry
	Corylus spp.	Hazel
	Pistacia vera	Pistachio

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria dispar	*Prunus domestica*	Plum
	Liquidambar styraciflua	Sweet gum (Strom, et al., 1996
Less Suitable: permitting feeding only from 2nd instar on young leaves, resulting in delayed development and small pupae.		
	Persea americana	Avocado
	Citrus spp.	Citrus fruits
	Prunus persica var. *Nucipersica*	Nectarine
	Prunus persica	Peach
	Pyrus spp.	Pear
	Puncia granatum	Pomegranate
	Rubus spp.	Raspberry
	Juglans spp.	Walnut
	Pinus taeda	Loblolly Pine (Strom, et al., 1996)
NOTE: Conifers usually attacked when growing in mixture with hardwoods (Baker, 1972). Important defoliators of forest trees in Europe and even more serious on forest trees and orchards in North America (Carter, 1984). The European strain has more than 250 known host plants but prefers oak. The Asian strain has a broader host range, including larch, oak, poplar, alder, willow, and some evergreens (USDA, 1992). A complete plant list is available in the EIS for gypsy moth, Appendix D (USDA, 1995). This list documents susceptibility by species on a scale of 1 to 3. See also Schaefer, at al., 1988 for recorded host plants in Japan.		
Lymantria dissoluta	*Taxodium* spp.	Cypress (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
	Pinus massoniana	Masson pine (Chung-Ling, 1992)
	Pinus sp.	Chinese pine (Chung-Ling, 1992)
Lymantria incerta	*Acer* spp.	Maple (Chung-Ling, 1992)
Lymantria juglandis	*Juglans* spp.	Walnut (Chao, 1984a)
Lymantria lapidicola	*Prunus dulcis*	Almond (Talhouk, A.S., 1977)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria lunata	*Anacardium occidentale*	Cashew
	Carica papaya	Papaya
	Citrus spp.	Citrus
	Impatiens spp.	Balsa tree
	Piper spp.	Pepper
	Pithecellobium dulce	Tamarind
	Psidium guajava	Guava
	Punica granatum	Pomegranate
	Santolina rosmarinifolia	Santol
	Solanum spp.	Eggplant
		Agoho
		Balimbing
		Duhat
		Sinigelas
All hosts as given in Holden, 1998.		
Lymantria marginata	*Castanea mollissima*	Chinese chestnut (Chung-Ling, 1992)
	Mangifera indica	Mango (Singh, 1989)
Lymantria mathura		(Tsia & Ding, 1982)
	Castanea sp.	Chestnut (Togashi, 1977)
		-For *L.* m. *aurora*
	Fagus grandifolia *	Beech, American (Zlotina, et al., 1998)
	Fagus sylvatica *	Beech, European (Zlotina, et al., 1998)
	Juglans mandshurica	Walnut, Manchurian (Zlotina, et al., 19982)
	Larix pp.	Larch (Odell, et al., 1992)
	Malus spp.	Apple (Holden, 1998)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria mathura	*Quercus mongolica*	Oak, Japanese (Odell, et al., 1992)
	Quercus variabilis	Oak, Oriental (Zlotina, et al., 1998)
	Quercus velutina *	Oak, black (Zlotina, et al., 1998)
Suitable hosts include Manchurian linden, apple, birch, beech, and willow, but Fagaceae are preferred (Zlotina, et al., 1998). Survival of 1st instar and further development on conifer species is low. The following conifers indicate survival of later instars (Zlotina, et al., 1998):		
	Abies nephroletis	Fir, a (Zlotina, et al., 1998)
	Pinus koraiensis	Pine, Korean (Zlotina, et al., 1998)
	Pseudotsuga mensiesii +	Douglas-fir (Zlotina, et al., 1998)
The study by Zlotina, et al., 1998 was also directed at determining which species of European and North American trees might be susceptible to attack. These species are indicated by the * above, but generally, broadleaf hosts, especially oaks and beeches and to a lesser extent, willows, apples, pears, cherries, birches, and mango are likely to be attacked.		
Lymantria modesta	*Rhus* spp.	Sumac (Pinhey, 1975)
	Sclerocarya birrea caffra	Marool-plum (Pinhey, 1975)
Lymantria monacha	*Abies alba*	Silver fir (Cwiklinski, 1989)
	Betula spp.	Birch (Fudala, 1983)
	Larix kaempferi	Japanese larch (Doom, 1979)
	Picea abies	Norway spruce (Cwiklinski, 1989)
	Picea sitchensis	Sitka spruce (Raske & Wickman, 1991)
	Pinus spp.	Pines (Schneider, 1981)
	Pinus contorta	Lodgepole pine (Raske & Wickman, 1991)
	Pinus nigra	Austrian pine (Grijpma, 1985)
	Pinus sylvestris	Scots pine (Vitola & Ozols, 1989)
	Quercus robur	English oak (Atanasov, 1980)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria monacha	*Fagus* spp.	Beech (Doom, 1979)

NOTE: Polyphagous on a wide range of broadleaved trees and conifers. Known as serious defoliators of conifers, especially spruce and broad-leaved trees in Europe, when damage can be devastating. Not a pest in Britain, where the larvae are mostly confined to Oak (*Quercus* spp.) (Carter, 1984).

In a study which paralleled the work by Zlotina, et al., 1998, on *L. mathura,* the following North American Hosts were indicated by rearing methods as those species which would likely be susceptible to *L. monacha* if it should become established in North American (Keena, 1999). This list does not include the "poor" hosts determined by the study, but does include several unrecorded European hosts.

INSECT	Scientific Name	Common Name
Lymantria monacha	*Abies concolor*	White fir
	Betula populifolia	White birch
	Carpinus caroliniana	American hornbeam
	Carya ovata	Shagbark hickory
	Fagus grandifolia	American beech
	Larix occidentalis	Western larch
	Malus sylvestris	Apple* no record, study "suitable"
	Picea glauca	White spruce
	Picea pungens	Colorado blue spruce
	Pinus ponderosa	Rocky mountain yellow pine
	Pinus strobus	White pine
	Pinus taeda	Frankincense pine
	Prunus serotina	Black cherry
	Pseudotsuga menziesii glauca	Rocky mountain douglas fir
	Pseudotsuga menziesii	Douglas fir
	Quercus alba	White oak
	Quercus lobata	California white oak
	Quercus rubra	Northern red oak
	Quercus velutina	Black oak

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria monomis	*Tilia cordata*	European linden* no record, study "marginal"
Lymantria monacha	*Tsuga canadensis*	Canadian hemlock
Lymantria monomonis	*Pinus* sp.	Pine (Chung-Ling, 1992)
	Taxodium spp.	Swamp Cypress (Chung-Ling, 1992)
Lymantria nebulosa	*Acer* spp.	Maple (Chung-Ling, 1992)
	Liquidambar formosana	Chinese sweet gum (Chung-Ling, 1992)
Lymantria ninayi	*Pinus* spp.	Pines (Roberts, 1978)
	Pinus patula	Mexican yellow pine (Mercer, 1990)
Lymantria obfuscata		Forest & ornamental trees (Adhikari, 1978)
	Alnus spp.	Alder (Roonwal, 1977)
	Cydonia oblonga	Quince (Masoodi & Srivastava, 1985)
	Juglans spp.	Walnut (Singh, et al., 1987)
	Malus spp.	Apple (Singh, et al., 1987)
	Populus spp.	Poplar (Roonwal, 1977)
	Populus alba	White poplar (Masoodi & Srivastava, 1985)
	Populus nigra	Black poplar (Masoodi & Srivastava, 1985)
	Prunus armeniaca	Apricot (Masoodi & Srivastava, 1985)
	Prunus avium	Cherry, sweet (Masoodi & Srivastava, 1985)
	Prunus dulcis	Almond (Masoodi & Srivastava, 1985)
	Quercus spp.	Oak (Roonwal, 1977)
	Salix spp.	Willow (Roonwal, 1977)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria xylina	*Acacia confusa*	(Chao, et al., 1996)
	Acer serrulatum	Maple, a (Chao, et al., 1996)
	Aleurites fordii	(Chao, et al., 1996)
	Averrhoa carambola	Carambola (Chao, et al., 1996)
	Bauhinia variegata	Mountain-ebony (Chao, et al., 1996)
	Bischofia javanica	Toog (Chao, et al., 1996)
	Callicarpa formosana	(Chao, et al., 1996)
	Camellia sp.	Camellia (Chang, 1991)
	Camellia oleifera	(Chao, et al., 1996)
	Camellia sinensis	Tea (Chung-Ling, 1992)
	Carpinus kawakamii	Ironwood, a (Chao, et al., 1996)
	Castanea mollissima	Chinese Chestnut (Chung-Ling, 1992)
	Castanopsis carlessii	(Chao, et al., 1996)
	Casuarina equisetifolia	Australian pine (Chao, et al., 1996)
	Casuarina glauca	Horsetail casuarina (Chang, 1991)
	Celtis sinensis	Hackberry (Chao, et al., 1996)
	Cinnamomum camphora	Camphor-tree (Chao, et al., 1996)
	Cyclobalanopsis glauca	(Chao, et al., 1996)
	Cyclobalanopsis longinux	(Chao, et al., 1996)
	Cyclobalanopsis stenophylla	(Chao, et al., 1996)
	Dimocarpus longan	Longan (Chung-Ling, 1992)
	Diospyros discolor	(Chao, et al., 1996)
	Diospyros eriantha	(Chao, et al., 1996)
	Disopyros khaki	Japanese persimmon (Chao, et al., 1996)
	Ehretia resinosa	(Chao, et al., 1996)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria xylina	*Ehretia thyrsiflora*	(Chao, et al., 1996)
	Elaeocarpus japonicus	(Chao, et al., 1996)
	Elaeocarpus serratus	(Chao, et al., 1996)
	Elaeocarpus sylvestris	(Chao, et al., 1996)
	Eriobotrya japonica	Loquat (Chung-Ling, 1992)
	Eucalyptus globulus	Blue gum (Chao, et al., 1996)
	Euphoria longana	(Chao, et al., 1996)
	Ficus carica	Fig (Chao, et al., 1996)
	Ficus microcarpa	Indian laurel fig (Chao, et al., 1996)
	Glochidion zeylanicum	(Chao, et al., 1996)
	Hibiscus tiliaceus	Sea hibiscus (Chao, et al., 1996)
	Lagerstroemia subcostata	Crape myrtle, a (Chang, 1991)
	Liquidambar formosana	Chinese sweet gum (Chung-Ling, 1992)
	Limlia uraiana	(Chao, et al., 1996)
	Litchi chinensis	Litchi (Chung-Ling, 1992)
	Macaranga tanarius	(Chao, et al., 1996)
	Mallotus japonicus	(Chao, et al., 1996)
	Mallotus paniculatus	(Chao, et al., 1996)
	Mangifera indica	Mango (Chao, et al., 1996)
	Melaleuca leucadendra	Weeping tea-tree (Chao, et al., 1996)
	Pasania brevicaudata	(Chao, et al., 1996)
	Pasania ternaticupula	(Chao, et al., 1996)
	Paulownia fortunei	(Chao, et al., 1996)
	Persea japonica	(Chao, et al., 1996)
	Persea thunbergii	(Chao, et al., 1996)
	Piper kadsura	Pepper, a (Chao, et al., 1996)
	Pithecellobium dulce	Guaymochil (Chao, et al., 1996)

INSECT:	HOST	
	Scientific Name	Common Name
Lymantria xylina	*Psidium guajava*	Guava (Chang, 1991)
	Pyrus pyrifolia	Pear (Chao, et al., 1996)
	Quercus acutissima	Sawtooth oak (Chao, et al., 1996)
	Quercus variabilis	(Chao, et al., 1996)
	Rhododendron sp.	Azalia, a (Chao, et al., 1996)
	Ricinus communis	Castorbean (Chang, 1991)
	Salix babylonica	Weeping willow (Chang, 1991)
	Salix warburgii	Willow, a (Chang, 1991)
	Schefflera octophylla	(Chao, et al., 1996)
	Scolopia oldhamii	(Chao, et al., 1996)
	Syzygium samarangense	Wax apple (Chao, et al., 1996)
	Terminalia catappa	Indian almost (Chao, et al., 1996)
	Thea sinensis	(Chao, et al., 1996)
	Trema orientalis	(Chao, et al., 1996)
	Vaccinium bracteatum	Berry, a (Chao, et al., 1996)
Ocnerogyia amanda	*Ficus carica*	Fig (Abai & Faseli, 1986)
Orgyia antigua		Deciduous trees (Baker, 1972)
		Coniferous trees (Baker, 1972)
	Calluna vulgaris	Scotch heather (Carter, 1984)
	Corylus spp.	Hazel (Carter, 1984)
	Cucumis spp.	Cucumber (Carter, 1984)
	Humulus lupulus	Hops (Carter, 1984)
	Malus spp.	Apple (Trenchev & Pavlov, 1982)
	Pyrus spp.	Pear (Trenchev & Pavolov, 1982)
	Prunus spp.	Plum (Trenchev & Pavlov, 1982)
	Prunus spp.	Cherry (Carter, 1984)
	Prunus armeniaca	Apricot (Carter, 1984)
	Picea spp.	Spruces (Svestka & Vankova, 1978)

INSECT:	HOST	
	Scientific Name	Common Name
Orgyia antigua	*Picea sitchensis*	Sitka spruce (Pinder & Hayes, 1986)
	Rosa spp.	Rose (Carter, 1984)
	Rubus spp.	Raspberry (Carter, 1984)
	Vaccinium myrtillus	Bilberry (Carter, 1984)
NOTE: Polyphagous, a minor pest of forest and orchard in Europe, including *Viburnum, Mahonia, Rhododendron, Pyracantha, Ceanothus, Larix, Pinus, Abies, Picea, Thuja, Pseudotsuga, Crataegus, Quercus, Fagus* and many other deciduous trees. Sometimes causes extensive defoliation of heather and bilberry and may damage larch and pine trees in the area.		
Orgya basalis	*Pinus patula*	Pine, Mexican yellow (Odendaal, 1980)
	Terminalia superba	Afara (Osisanya, 1976)
Orgyia (=Hemerocampa) definita	*Salix* spp.	Willow
	Malus spp.	Apple
	Prunus ilicifolia (several spp.)	Wild cherry
	Ulmus spp.	Elm
	Betula papyrifera	Paper birch
	Quercus spp. (Several red oaks)	Red oak
	Acer rubrum	Red maple
	Fraxinus spp.	Ash
NOTE: Species listed are by Baker, 1972.		
Orgyia detrita	*Magnolia virginiana*	Sweetbay magnolia (Drooz, et al., 1986)
	Quercus virginiana	Southern live oak (Drooz, et al. 1986)
	Rhododendron spp.	Azalea (Drooz, et al., 1986)
Orgyia Heteronygmia dissimilis	*Khaya nyasica*	African mahogany (Rwamputa & Schabel, 1989)

INSECT:	HOST	
	Scientific Name	Common Name
Orgyia ericae	*Vaccinium myrtillus*	Bilberry (Pupavkina, 1985)
		Not known (see Zhang, et al., 1991)
Orgyia gonostigma	*Betula* sp.	Birch (Chung-Ling, 1992)
Orgyia gonostigma	*Corylus colurna*	Hazel, turkish (Chung-Ling, 1992)
	Malus syslvestrus	Apple (Trenchev & Pavlov, 1982)
	Populus sp.	Poplar (Chung-Ling, 1992)
	Prunus armeniaca	Apricot (Sevryukov, 1979)
	Prunus avium	Cherry, sweet (Chung-Ling, 1992)
	Prunus domestica	Plum (Trenchev & Pavlov, 1982)
	Pyrus communis	Pear (Trenchev & Pavlov, 1982)
	Quercus sp.	Oak (Chung-Ling, 1992)
	Rosa sp.	Rose (Chung-Ling, 1992)
	Salix sp.	Willow (Chung-Ling, 1992)
Orgyia leucostigma	*Abies balsamea*	Balsam fir (Embree, et al. 1978)
	Betula papyrifera	White birch (West, et al. 1989)
	Juglans nigra	Black walnut (Wilson, 1991)
	Platanux occidentalis	Sycamore (Thompson & Solomon, 1986)
	Zea mays	Corn (Foott & Timmins, 1977)
		(Grant, 1981)
Orgyia (=Hemercoampa) leucostigma	*Abies balasamea*	Balsam fir
	Acer platanoides	Norway maple
	Acer pseudoplatanus	Sycamore maple
	Acer saccharum	Silver maple
	Betula alleghaniensis	Yellow birch
	Betula papyrifera	Paper birch
	Betula sp. *Platyphylla*	Sycamore birch
	Larix sp.	Larch
	Malus domestica	Apple

INSECT:	HOST	
	Scientific Name	Common Name
Orgyia (=Hemercoampa) leucostigma	*Populus* spp.	Poplar
	Tilia americana	Basswood
	Ulmus spp.	Elm
NOTE: Preferred species by Baker, 1972.		
	Cassia fistula	Indian laburnum (Maharaj & Patil, 1986)
	Mangifera indica	Mango (Maharaj & Patil, 1986)
	Terminalia arjuna	(Maharaj & Patil, 1986)
Orgyia mixta		Cereals (Walker, 1994)
Orgyia prisca	*Malus* spp.	Apple (Akhmedov, 1982)
	Cydonia oblonga	Quince (Akhmedov, 1982)
Orgyia postica	*Glycine max*	Soybean (Su, 1986)
	Theobroma cacao	Cocoa (Pardede, 1986)
	Malpighia glabra	Barbados-cherry (Subba-Rao, et al., 1974a)
	Mangifera indica	Mango (Gupta & Singh, 1986)
	Lablab purpureus	Hyacinth bean (Subba-Rao, et al., 1974a)
	Leucaena leucocephala	Lead tree (Pardede, 1986)
	Rosa sp.	Roses (Wang, 1982a)
	Tamarix juniperina	Salt-cedar, a (Subba-Rao, et al., 1974a)
	Vigna radiata	Mung bean (Su, 1987)
	Vitis spp.	Grapes (Wu, 1977)
	Vitis vinifera	Grape (Chang, 1988)
Orgyia pseudotsugata	*Pseudotsuga menziesii*	Douglas fir (Linnane & Steizer, 1982)
	Abies spp.	True fir (Linnane & Steizer, 1982)
	Abies concolor	White fir (Mason, 1981)
	Abies grandis	Giant fir (Heller & Sader, 1980)

INSECT:	HOST	
	Scientific Name	Common Name
Orgyia pseudotsugata	*Picea engelmanni*	Engelmann spruce (Linnane & teizer, 1982)
	Picea pungens	Colorado blue spruce (Linnane & Steizer, 1982)
		Forest trees (Anderson & Kaya, 1976).
		See Brooks, et al., 1978, for a complete list.
Orgyia thyellina		See Sato, 1979 and the OEG EIS, 1996.
	Malus spp.	Apple (Sato, 1977)
	Pyrus spp.	Pear (Sato, 1977)
	Prunus domestica	Plum (OEG EIS, 1996)
	Prunus persica	Peach (OEG EIS, 1996)
	Prunus spp.	Cherry (OEG EIS, 1996)
	Rosa spp.	Roses (OEG EIS, 1996)
	Salix spp.	Willow (OEG EIS, 1996)
		Kakabeak (OEG EIS, 1996)
	Citrus x *paradisi*	Grapefruit (OEG EIS, 1996)
	Acer negundo californicum	California box elder (OEG EIS, 1996)
	Betula spp.	Birch (OEG EIS, 1996)
	Quercus spp.	Oak (OEG EIS, 1996)
	Wisteria spp.	Wisteria (OEG EIS, 1996)
	Pelargonium spp.	Geranium (OEG EIS, 1996)
	Erythrina spp.	Coral pea (OEG EIS, 1996)
Orgyia vetusta	*Arctostaphylos* spp.	Manzanitas
	Atriplex spp.	Saltbushes
	Cassia spp.	Shower trees
	Ceanothus spp.	Red-roots
	Crataegus spp.	Hawthorns

INSECT:	HOST	
	Scientific Name	Common Name
Orgyia vetusta	*Franseria chamissonis*	
	Juglans spp.	Walnuts
	Lupinus spp.	Lupines
	Malus spp.	Apples
	Photinia spp.	Photinias
	Prunus spp.	Plums, cherries
	Pyrus spp.	Pears
	Quercus argrifolia	California live oak
	Quercus spp.	Oaks
	Rhamnus spp.	Blackthorns
	Rubus spp.	Blackberries
	Salix spp.	Willows
Hosts from Savela, 1998.		
Pantana phyllostachysae	*Phyllostachys edulis*	Edible bamboo (Chao, 1977)
Pantana sinica	*Phyllostachys edulis*	Bamboo (Wei, 1987)
Parocneria furva	*Taxodium* spp.	Cypress (Chung-Ling, 1992)
	Juniperus chinensis	Juniper (Chung-Ling, 1992)
Perina nuda	*Artocapus heterophyllus*	Jackfruit (Butani, 1978a)
	Eucalyptus citriodora	Lemon-scented gum (Ghorpade & Patil, 1991)
	Ficus benghalensis	Banyan (Chung-Ling, 1992)
	Ficus spp.	Fig (David & Paul, 1975)
Pida strigipennis	*Cinnamomum camphora*	Camphor (Chung-Ling, 1992)
	Cinnamomum aromaticum	Chinese cassia tree (Chung-Ling, 1992)
	Mangifera indica	Mango (Chung-Ling, 1992)
	Quercus spp.	Oak (Chung-Ling, 1992)
Porthesia atereta	*Camellia sinensis*	Tea (Chung-Ling, 1992)

INSECT:	HOST	
	Scientific Name	Common Name
Porthesia atereta	*Castanea molissima*	Chinese chestnut (Chung-Ling, 1992)
	Juglans spp.	Walnut (Chung-Ling, 1992)
Porthesia kurosawai	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Citrus sinensis	Orange, sweet (Chung-Ling, 1992)
	Malus spp.	Apple (Chung-Ling, 1992)
Porthesia piperita	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Catalpa ovata	Chinese catalpa (Chung-Ling, 1992)
	Leguminosae	Legumes (Chung-Ling, 1992)
Psalis pennatula	*Juniperus chinensis*	Juniper (Chung-Ling, 1992)
	Orzya sativa	Rice (Sethi & Garg, 1983)
	Saccharum officinarum	Sugarcane (Chung-Ling, 1992)
	Zea mays	Corn (Chung-Ling, 1992)
Redoa anser	*Camellia sinensis*	Tea (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Redoa anserella	*Camellia sinensis*	Tea (Chung-Ling, 1992)
	Camellia sasanqua	Oil-tea camellia (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Redoa cygnopsis	*Camellia sinensis*	Tea (Chung-Ling, 1992)
Redoa phaeocraspeda	*Camellia sinensis*	Tea (Chung-Ling, 1992)
		Forest trees (Wang, 1982)
Rolepa unimoda	*Tabebuia impetiginosa*	Trumpet tree, Mexican rose (Peres-Filho & Berti-Filho, 1985)
	Tabebuia aurea	Trumpet tree, silver (Peres-Filho & Berti-Filho, 1985)
Stilpnotia melanoscela	*Populus* spp.	Poplar (Chung-Ling, 1992)
	Salix spp.	Willow (Chung-Ling, 1992)
	Ulmus spp.	Elm (Chung-Ling, 1992)
Varmina indica	*Malus domestica*	Apple (Chander & Dogra, 1983)

ADDENDUM 4

Technical Survey Information

Cross Transect Survey

Draw two straight lines on a map that will intersect each other and run through:

- High risk suburban/urban areas whose residents are likely to travel to lymantriid-infected areas.
- Host production areas
- Areas where hosts are in abundance (backyards, etc.)
- Coastal areas where hosts are available.

The lines should both bisect the area under survey. They do not need to be perpendicular to each other, but should both run through the most suitable local sites that have been identified.

Examine all hosts along the transit. If there are many hosts along the transit (as in a field or grove), select 1 out of every 10 most likely localities. A minimum sample along any one transit should be 10 host localities. Another approach is to draw up a list of 5-10 high preference hosts for the survey, based on those hosts preferred by the target pest in the program area, and which, insofar as is possible, are also **not** preferred hosts of local lymantriid species.

Survey Procedures:

Sequential sampling system. Sequential sampling may be necessary as an aid to decision making. The objective is to estimate the level of pest density at moderate densities using a fixed level of sampling precision, or to low population densities using a critical density level. These densities are those most likely to be encountered in the early stages of an invasion of an exotic pest.

A system designed for *Orgyia pseudotsugata* may be helpful (Shepherd, 1985a). With this technique, early instar larvae are collected by beating three lower branches from each of a number of hosts picked in a predetermined fashion. There will be a predetermined number of samples that will be required to accurately determine the pest densities, depending on hosts, the target pest concerned, and the area involved.

A somewhat similar system was designed for egg-masses for the same species (Shepherd, 1984). In this case, one branch from the lower whorl of branches of a non-defoliated host is examined to count the number of egg masses found. This is repeated for 60 other host plants in 10 delimitated areas. Such a procedure was originally designed as an early detection tool for non-defoliated stands in the incipient stage of an outbreak, but can be adapted for the early stages of an invasion of an exotic lymantriid pest.

Inspection Procedures:

NPV Bioassay. A NPV bioassay may be necessary to determine the progress of an epizootic, either natural or initiated through control measures. It may be needed not only to check the exotic pest population, but also to ascertain if non-target insect populations are under pressure as well; and to determine, if more than one NPV is used, the effect of each.

The simplest means of carrying out an assay is to collect live specimens which appear to be infected, sick or from a location or site where other individuals are already moribund or dying. Each collection is to be maintained separately. The collected specimens may be maintained until death in a waxed paper cup (capacity 255 ml), then inserted into another, smaller (199 ml) cup with a water reservoir. Foliage from the host plant will be maintained in fresh condition for up to 2 weeks. Upon death of any of the specimens, the body will be carefully removed for examination. The paper-cup container will be disposed of so that other material is not contaminated (Kaupp, 1982).

Surveys of other types of pathogens may need to be devised to determine their impact on target and nontarget populations, if applicable for program purposes.

Traps:

Table A lists, as far as is known, key trapping elements for many of the lymantriid species. The pheromone compounds for each species are listed as well. Non-economic species not otherwise listed in this document are included for comparative purposes. Note that there are many blanks in the table, owing to lack of information on even simple things such as flight times of many of the species involved.

Table A: Key Trapping Elements For Any Proposed Lymantriid Survey Program

Species	Pheromone	Sex Attracted	Flight Activity	Female Capable of Flight	Trap Type
Calliteara pudibunda			Nocturnal; April/May July/August	Yes	Light
Dasychira grisefacta ella	Z6-21-11Kt (Arn, et al., 1986)				Pheromone
Dasychira plagiata	Z6-21-11Kt (Arn, et al., 1986)				Pheromone
Dasychira vagans grisea	Z6-21-11Kt (Arn, et al., 1986)				Pheromone
Euproctis chrysorrhoea	7Z13Z16Z19Z isobutyrate (Leonhardt, et al., 1991)	Male	Nocturnal; June/August	Yes	Light Pheromone
Euproctis lunata			Nocturnal; August/Nov	Yes	Light
Euproctis pseudoconspersa	10Me14Me-15: iBu 14Me-15: iBu 10Me14Me-15: nBu (Wakamura, et al., 1994)	Male	Nocturnal	Yes	Pheromone
Euproctis similis xanthocampa	Z7-18-isovalerate a 6-18-isovalerate 6-18-n-valerate (Arn, et al., 1986)		Nocturnal; July/August	Yes	Light Pheromone
Euproctis subnotata			Nocturnal		Light
Euproctis taiwana	(Z)-16-methyl-9-heptadecenyl iobutyrate 16-methylheptacecyl isobutyrate (Yasuda, 1995)	Male	Nocturnal	Yes	Pheromone
Gynaephora ginghainensis	Z3Z6Z9-21Hy Z3Z6Z9-20Hy (Arn, et al., 1986)		Diurnal	No	Pheremone
Heteronygmia dissimilis			Generally Nocturnal; 4 generations/ year/All stages found	Yes	Light

Species	Pheromone	Sex Attracted	Flight Activity	Female Capable of Flight	Trap Type
Leucoma salicis	3Z-cis-6,7-cis-9,10-Diepoxy-heneicosene (Gries, et al., 1997c)		Duurnal/Mainly Nocturnal; 1-3 gen/year	Yes	Light Pheromone
Lymantria concolor	disparlure (Bhardwaj, 1987)	Male	Nocturnal	Yes	Pheromone
Lymantria dispar	disparlure (Anon., 1990) cis-7,8-epo-2Me-18Hy(+) (Arn, et al., 1986)	Male	Diurnal; July to September --------- Diurnal	No ----------- Yes (East Asia)	Delta Milk Carton Milk Carton Delta (Marshall & Clark, 1984)
Lymantria dispar japonica	cis-7,8-epo-2Me-18Hy (Arn, et al., 1986)	Male	Diurnal	Yes	Light? Pheromone
Lymantria fumida	cis-7,8-epo-2Me-18Hy (Arn, et al., 1986); (+)-disparlure and 2me-Z7-18Hy (Schaefer et al., 1999?)	Male	Nocturnal; esp. Males 8-12 pm	Yes	Pheromone Sticky trap only/do not use milk carton
Lymantria marginata	(+)-disparlure (Schaefer, unpub. data)	Male	Nocturnal, esp. before dawn	Yes	Light
Lymantria mathura	(+) -disparlure (Odell, et al., 1992) (9R,10S)-cis-9,10-epoxy-Z3,Z6-nonadecadiene and (9S,10R-cis-9,10-epoxy-Z3,Z6-nonadecadiene (Gries, et al., 1999a) Z,Z,Z-3,6,9-nonadecadiena 4a and Z,Z-(9S,10R)-9,10-epoxy-3,6-nonadecadiene (Oliver, et al., 1998)	Male	Nocturnal	Yes	Milk Carton
Lymantria monacha	disparlure (Schneider, 1981) cis-7,8-epo-2Me-18Hy (-) " (+) " (Arn, et al., 1986) (±)-disparlure and (±)-monachalure and 2-methyl-Z7-octadecene (Gries, et al., 1997a)	Male/Female Males	Nocturnal; August/Sept	No Yes in Siberia, Far East, Japan	Light 3 - D Sticky Delta Traps

Species	Pheromone	Sex Attracted	Flight Activity	Female Capable of Flight	Trap Type
Lymantria obfuscata	cis-7,8-epo-2Me-18Hy (Arn, et al., 1986)	Male	Diurnal	No	Pheromone
Lymantria xylina	cis-7,8-Epoxy-2-methyl-Z7-eicosene (Gries, et al., 1999b?)	Male	Nocturnal	Yes	Sticky or Milk Carton
Orgyia antiqua	Z-6-heneicosen-11-one (Grant & Frech,1980) Z6-21-11Kt (Arn, et al., 1986)	Male	2-3 generations; June August Sept/October	No	Pheromone
Orgyia cana	Z6-21-11Kt (Arn, et al., 1986)	Male	Nocturnal	No	Pheromone
Orgyia gonostigma	atraorg (Z6-21-11Kt) (Romania) (Minoiu & Boaru, 1989)	Male	Nocturnal	No	Pheromone
Orgyia leucostigma	Z6-21-11Kt (Arn, et al., 1986)	Male	Nocturnal	No	Pheromone
Orgyia pseudotsugata	Z-6-heneicosen-11-one (Daterman & Sower, 1977; Shepard, et al., 1985) Z6-21-11Kt (Arn, et al., 1986) (Z)6,(E)8-Heneicosadien-11-one (Gries, et al., 1997b)	Male	Nocturnal	No Larvae disperse by means of silken threads to adjacent stands of host	Sticky Delta
Orgyia thyellina	Z-6-heneicosen-11-one (OEG EIS, 1996) and (Z)6-heneicosen-9-one (Gries, et al., 1999c)	Male	Nocturnal in summer/diurnal in autumn; 2-3 generations a year	Yes in summer No in autumn Larvae also balloon silk threads	Light in summer only Pheromone
Pantana sinica			3 generations April/Aug June/Oct Sept/Dec		

1. Pheromone Trapping. In tussock moths, pheromonal responses are one of several mechanisms used to isolate sympatric species. Because some individuals may respond to some degree to a pheromone of another species, it is of greatest benefit to employ a pheromone specific for the target species. (Grant, 1977)

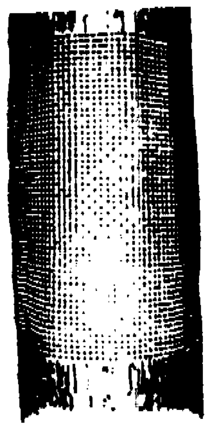
In addition, a pheromone trap is more likely to pick up specimens of the target species. For *Lymantria monacha*, for example, the radius of attraction is about 200 meters. By comparison, females of that species can only attract males from a distance of 85 meters, less than half the distance of the pheromone trap. (Jahn, 1979; see also Egger & Brandl, 1986)

Pheromone trapping will be the method of choice if a species responds to a pheromone. Using the site of the first (original) detection as the focal point (epicenter), the appropriate number of traps of the type designated for that species will be set out in the core and first and second buffer areas in a standard grid array. The traps are baited with the appropriate pheromone as given above. Details of baiting, the lure, its concentration, amount, the type of dispenser (cotton wick, laminated plastic, controlled release, etc.) employed will depend on the program and the lymantriid species involved. These details are **critical**. For example, a dosage of .5 mu kg/trap of disparlure is optimal for *Lymantria dispar*, but is not enough for *Lymantria monacha*, which needs 5 mu kg/trap (Bednyi, et al., 1981). (However, Gries & Gries, 1997, have come up with a new 3-component blend for *Lymantria monacha* which seems to have overcome this problem -see Table.)

Traps will be serviced every week to 2 weeks, depending on program needs and determination of frequency. Place traps on or near hosts. Traps will be maintained through three estimated generations of the target lymantriid species after the date of the last detection.

a. Grid trap. The grid trap is a sticky type trap with a generous trap capacity. It is extremely simple, consisting of a 0.25" (0.64 cm) mesh hardware cloth cut into a 30.5 cm x 35.5 cm rectangle. This is simply stapled to the trunk of a tree with a pheromone dispenser under it and coated with tangletrap. It is serviced on a 1- to 2-week schedule, depending on the lymantriid's biology and program needs. The chief disadvantage is exposure of lymantriid specimens to predators and the elements (Mastro, et al., 1977). This may not matter in cases where it is used for mass trapping.

Grid trap

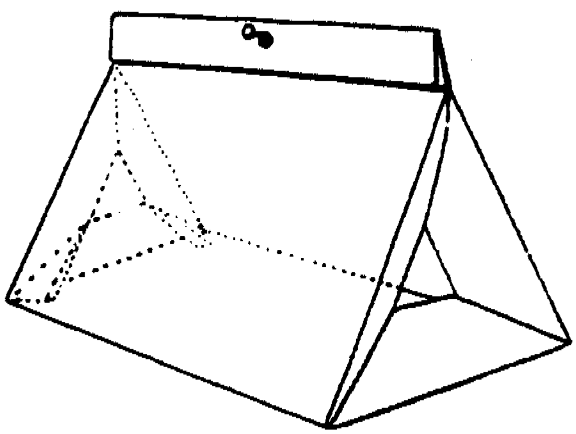


b. Delta/Pherocon traps. The Delta trap is a sticky type trap with a limited catch capacity. The dispenser, loaded with the pheromone, is stapled to a non-sticky side, usually marked with an X. The trap is then folded and stapled to a host. Entrance flaps must be folded out in the "open option" for lymantriids. It is serviced on a 1- to 2-week schedule, depending on the lymantriid's biology and program needs (USDA, 1992).

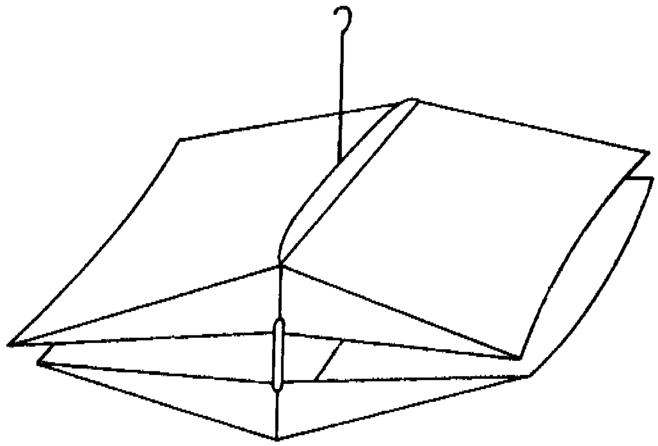
The Pherocon 1C trap is modified for lymantriids by the addition of a thick layer of tanglefoot on the inside surfaces of both top and bottom halves and increasing the opening between the two halves from a standard 2 cm to 11 cm. It is hung from a host and is serviced as above (Elkinton & Carde, 1980; Elkinton & Childs, 1983).

These traps are useful in low-density situations or when a target lymantriid is surveyed for in an area where it is not known to occur. The Pherocon 1C, as modified, may be better able to capture moths than the smaller Delta trap and thus have a somewhat better ability to make that first detection. Some experimentation may be necessary to determine which trap is actually the better trap for the target species in question.

Delta Trap



Pherocon 1C Trap



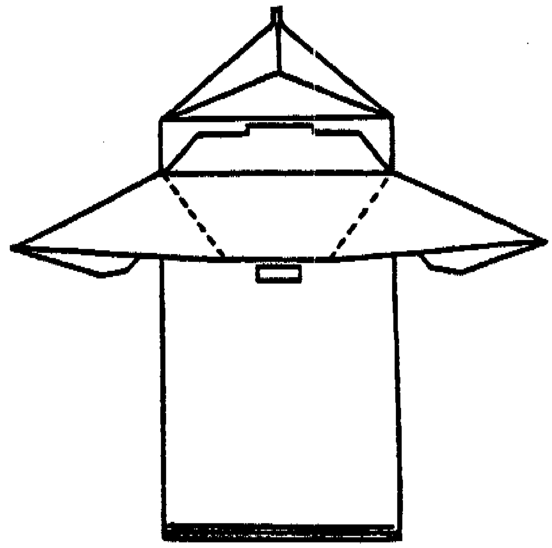
c. Milk Carton trap. Used in the same way as a Delta trap, except it has a far greater capacity and is employed when 12 or more moths may be trapped per catch/period. This would include non-target species (or strains) which may be attracted to the lure.

Since this trap is of the non-sticky type, a DDVP insecticide strip (Vapona®) is incorporated into the trap. The strip is stapled to one end of a 7-inch twist tie with the pheromone stapled about half way up the twist tie. The top of the twist tie is then stapled to the top of the trap, with the pheromone and DDVP suspended inside (USDA, 1992).

A variation on this trap is the Universal moth trap (Unitrap) (Great Lakes Catalog, 1995). This trap closely resembles the Czechoslovak dry pot trap recently developed (Hochmut, et al., 1989). Both are baited with the pheromone and DDVP strip inside. However, the Unitrap gives dismal performance for the gypsy moth, and its efficiency would have to be evaluated for any given target species.

Another variation under development by APHIS involves putting two milk cartons together to increase the size and hence the catch efficiency of the trap. This was actually in response to the collection of sulfur moths, which are much larger than tussock moths, but may well work for the latter as well. Contact Dr. Victor Mastro, Otis Plant Methods Center for up-to-date information. (Anon., 1999; Paszek & Schwalbe, 1980)

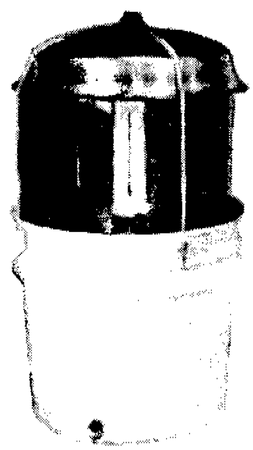
Milk Carton Trap



2. Blacklight trapping. This trap will attract night-flying moths only, as well as many other insects. It is a good way to find out if a lymantriid with a night-flying female is present in an area, as both sexes are attracted to light. It is also an alternative when no pheromone is available for a night-flying moth.

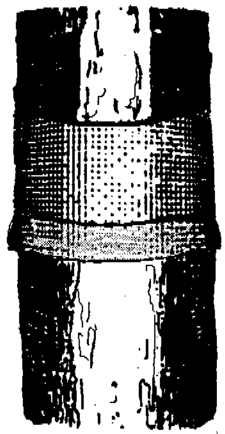
Blacklight traps are to be serviced each morning on a daily basis. As this system is labor intensive, it should be used only in core and buffer areas in or near detections or where large numbers of host plants are found (Stibick, 1991).

Blacklight Trap



3. Shelter trapping. Generally used when no pheromone is available and blacklight trapping would be ineffective for daytime flying lymantriids. There are two types of shelter trapping available.

(1). Burlap banding. Burlap bags are cut into strips roughly 12 inches wide, folded in half, and tied around the trunk of a host tree or large bush. Inspection is made by lifting the strip to see if any larvae or pupae are under the shelter.



Burlap Bagging

(2). Wood block shelters. Wood block shelters may be attached to host trees to determine if the target lymantriid population is present, and if so, in roughly what density. Both egg masses and pupae will be found in shelters (Dahlsten, et al., 1992). The wood blocks (see Figure 1) should be at a height of 15 feet (4.6 meters) for optimum catch (McManus & Smith, 1984). In practical terms however, this may vary, depending on the type and size of host plants and other limitations. Another type of wood block shelter is made into a flat box with a single entrance (see Figure 2). These are used to collect gypsy moth eggs in very low population situations in the Eastern United States. Although not particularly cost effective, they do encourage larval resting, pupation, and egg laying (Schaefer, manuscript only).

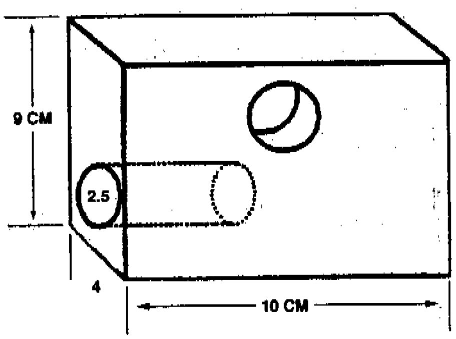


Figure 1

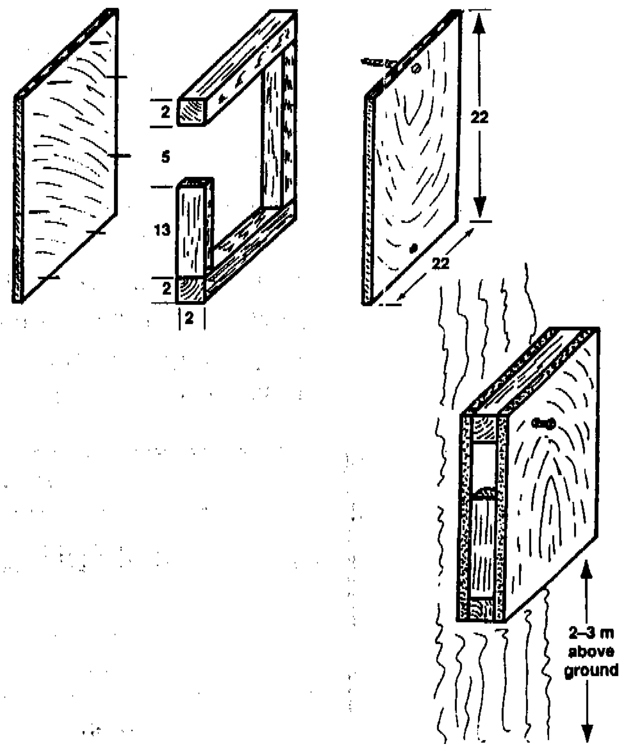


Figure 2

Wood Block Shelters

d. Passive traps. Empty jars and jars with soapy water are examples of passive traps. These are relatively inefficient and should be used only when no pheromone is available and shelter trapping will not produce results (see Lindgren, et al., 1984).

Sticky panels are another example of a passive trap. These can be used with or without an attractant, but are relatively difficult to service and specimens are exposed to various environmental factors. Their redeeming feature is a potential high trap catch, which is useful for detection of a low density population. Hochmut, et al., 1989, used a 50 x 50 cm metal square trap in Czechoslovakia. In the United States, it is suggested that sticky sheets, such as Olson sticky strips (Great Lakes Catalog, 1995) be used. Three 6 x 12" strips are roughly equivalent to the metal square in surface area.

e. Trap Mounting. For the most part, traps are to be mounted on the host. Under certain circumstances it may be desirable not to hang traps from the host or other suitable support, or support (such as trees) is sparse or lacking entirely. There are several possibilities:

- The location requires that a trap or traps be set there
- The presence of herbaceous host(s) requires that a trap or traps be set there

In these cases, a trap can be hung with galvanized wire from the top of a 6 foot 3/4" PVC pipe set into the ground (Fellen & Hengel, 1983).

f. Trap Distances. Unless otherwise specified, traps, especially pheromone traps, should be spaced in a grid system. This ensures proper trap distribution. The following table shows distances between traps for various trap densities for detection and delimiting surveys.

Distances for Trap Densities	
Traps per square mile	Distances between traps in feet
.25	10,540
1.00	5,280
16.00	1,320
25.00	1,056
36.00	880

(Anon., 1990)

g. General Trapping Guidelines (USDA, 1992). The trapping guidelines given here are generally those for gypsy moth. Other species may have different requirements, especially regarding the placement and height of a trap. Information specific to a given species will have to be developed during a program for that species. However, since detections are critical to program implementation, there should be **no delay** in setting the trapping system up for the sake of obtaining such specific information.

(1). Try to place traps on or near preferred host plants. If the host is a tree, then trees 0.5 meters in diameter or better are to be preferred (Carde, et al., 1977).

(2). Moths tend to follow woodland edges and lines of tree growth. They do not travel to open areas where there are no trees or shrubs unless the host(s) are herbaceous, such as certain field crops. However, small clumps of trees or fence lines with host material should not be ignored.

(3). If available, woodland edges are the best positions in a trap site. Traps are most effective when placed at or near a woodland corner. If there is a choice, place pheromone traps on the windward side so the prevailing wind currents will carry the pheromone scent into the woods. Blacklight and passive traps should be placed on the leeward side so that moths will tend to fly or drift down towards them.

(4). If there are no woodlands or residential positions within a reasonable distance (500 to 1,000 feet) from the plotted site, then the best position for a trap is at the end of a hedge row or tree leading to a wooded area.

(5). The trap should be placed on a tree trunk, pole, or other vertical structure about 4 to 5 feet up. Hanging the trap from a tree limb will decrease its efficiency. Place the trap out of reach of children or livestock. If a given lymantriid species has a known flight height, use that flight height for the trap. In some cases it may be advantageous to face the trap to the south side of a tree or other host, as these may catch the most moths, followed by those facing west, those facing east, and those facing north (Capek, 1979).

(6). Avoid omitting traps. Trap positions can be moved up to one-third the inter-trap distance to adjust for local conditions.

(7). Do not set the trap where foliage, branches or other objects may block trap openings.

(8). Whenever possible, avoid setting traps on or in the following places:

- Close to a gravel road (keep trap at least 50 feet away).
- Properties that are for sale.
- Parks or open areas where people can easily see the traps.
- Properties with aggressive dogs.
- Private property without the owner's permission.
- School properties or passageways where students walk.
- Places where farm animals may damage or destroy traps.
- Sites where road construction is scheduled or in progress.
- Sites within locked gates.
- Trees with poison ivy vines.
- Trees marked for cutting or removal.

(9). There are some general rules for blacklight traps.

- Since it attracts insects from no more than 200 feet as a rule, best results occur when traps are placed where there is a 180° arch of visibility, within 200 feet of hosts.

- Place in areas with minimal interference (say 500 feet away) from other light sources.

- Place near a light reflecting surface to increase the pulling power of the light.

- Place close to potential host plants adjacent to areas where incoming traffic from infested areas or incoming ships from infested areas are unloaded, handled or used, including recreational areas and along waterways.

- Keep clear of obstructing vegetation or structures.

- Place some distance from the edge of a clump of trees and raise the light off the ground for increased effectiveness.

<u>Visual Survey</u> (Stibick, 1991)

If delimitation of an infestation in as short a time frame as possible is critical and there are significant differences in the biology or appearance of the exotic lymantriid that can be utilized by a visual survey, then this element can be integrated into program efforts. A visual survey may also take on more importance if the exotic lymantriid does not respond to a known pheromone, is day-flying, and whose eggs are laid on the host plant with little or no larval movement or migration. Examples of differences which may be utilized are:

- Times of emergence of the life stages.
- Differences in timed appearances of larvae/eggs/adults.
- Places where eggs or pupae may be found.
- Host plants where exotic arthropods/lymantriids may be found.
- Movement of larvae.
- Characteristics of overwintering or dormant stage(s).

Using the site of the first detection as the focal point, locate up to 16 host areas within the mi^2 or 4 mi^2 core area. Each area will be sampled at five locations. A minimum of 50 hosts (10 hosts from each location) will be examined for the presence of eggs, larvae, pupae, and adults, depending on applicability for the time of year involved and the presumed life stages available. Inspect host or surrounding area in conformity with the biology of the target species.

Very large host areas, such as a forest, should be divided into smaller units, and each unit counted as a separate area with a maximum of 10 acres. Not all such units should be sampled at the same time, in order to keep spacing of sample areas roughly equal.

To improve survey effectiveness, it should be conducted during favorable weather and periods of insect activity. However, since a life stage is always available anytime of the year, it may be possible to carry out a visual survey at any time if there are distinctive characteristics or behavior of the target lymantriid that can be used to advantage.

If sufficient host areas are available, the visual survey will be repeated once a week in different areas. The survey will be repeated once a week in different designated areas. The survey will last for at least three estimated generations of the target lymantriid. Areas will be rotated to allow coverage of the entire core area over each 4-week period.

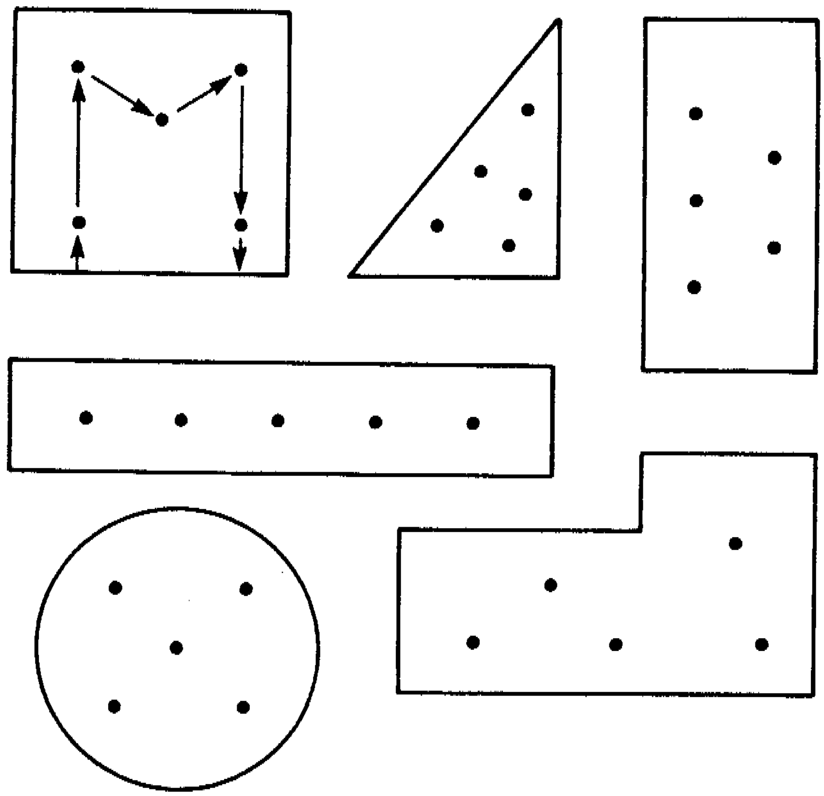
<u>Visual Survey Procedure</u>

Samples should be equally spaced, unless damaged areas are noted. Damaged areas with partly or completely eaten leaves or which exhibit poor growth receive priority in the survey.

In addition to the above area survey, check borders, fence rows, and ditch banks for suitable hosts, especially near roads or waterways. If suitable hosts are found, a separate survey may be taken, particularly if it is in the core area.

Sampling within the designated area should follow a similar pattern for each area being surveyed. When collecting samples within designated areas, take samples at least 75 feet from the edge from five different locations in the area. Move from location to location, following a predetermined pattern such as given below:

Field Survey Pattern



At each of the five sample locations, inspect a minimum of 10 hosts, with a bias toward those hosts showing signs of chewed leaves, or poor growth.

Look for the following lymantriid life stages at the appropriate time of the year, based on the life cycle as determined by the project:

Eggs: Look for clusters of 10 to 500 or so egg masses covered by silken webbing and hair scales, etc., in areas dependent on the lymantriid species involved.

Larvae: Check leaves and under bark, etc., dependent on the lymantriid species involved.

Pupae: Check cracks, crevices, etc., for cocoons, wherever the biology of the pest may dictate this stage to pupate.

Adults: If females are flightless, they may be found on the host. If they fly, they could be anywhere.

Adults should be caught and saved for identification. If distinctive, larvae may also be saved for identification, otherwise they should be collected with sufficient host for rearing purposes, as should any suspect egg masses found.

ADDENDUM 5

Technical Control Information

Biological Control

Microorganisms
Juvenile hormones - Insect growth regulators
Plant Extracts
Pheromones
Parasites & Predators

A basic goal of classical biological control is to control target pests without harming nontarget organisms. To do this, the introduced biocontrol agent must be relatively host-specific. Host specificity is often determined only after release of the agent into the environment. Much is known about the host specificity of biocontrol agents before they are released.

Lab studies attempt to determine the physiological host range of the agent to predict the ecological host range. This data must be interpreted carefully when nontarget possible hosts are exposed to the agent under the confined circumstances of the lab. Many conditions in the outside environment determine which possible hosts are attacked, such as spatial or temporal overlap, host ranges and/or substrates of target and nontarget species, temperature and humidity tolerances, and others (Solter, et al., 1997; Hajek, et al., 1996). In any case, the error, if any, is conservative. Ecological host ranges are almost always much narrower than the physiological host range.

Because entomophagous species respond to a complex of chemical and physical clues from the environment, host plant, and target host, key determinants of host specificity may occur at any of these levels and be absent in simplified laboratory tests. Therefore, greater reliance needs to be placed on other measures of host range in making safety assessments of entomophagous insects; for example, field studies in the country of origin, to determine the natural host range with special regard to the determination of factors that delimit the niche occupied by the candidate natural enemy.

Biocontrol agents must be carefully considered for their possible impact on nontarget organisms.

Some general rules are followed:

1. Predators usually have wider host ranges in their actions than parasites.
2. The known host specificity of an agent, including information on behavior of related taxa.
3. Selection of agents known to only attack certain target or closely related non-target species.

To this end, information on the available controls are given in table form to allow comparisons between different lymantriid species as a decision-making tool and to help in the selection of the best combination of BI for a given invading pest.

In Table A, Biological Agents are given separately under each species. The Products are numbered under each agent.

It should be remembered that pests may develop non-genetic as well as genetic resistance. Their behavior or physiology may change. There may be changes in host plant interference with pesticide action, including microbial pesticides such as entomopathic bacteria and viruses. These pesticides are particularly sensitive to plant chemistry because they infect through the gut. As a consequence, the composition of foliage ingested with the microbial pesticide can dramatically influence the pesticide's effectiveness (Appel & Schultz, 1994).

Another factor to consider is rainfall. It has been suggested that a light rainfall may help in prolonging the period of activity of viral preparations by moving the virus downwards, towards the more shaded parts of a plant and away from light. This would help to prolong its effectiveness. However, this hypothesis is unproved (D'Amico & Elkinton, 1995). The same assumptions may perhaps be made about fungal preparations.

TABLE A. Microorganisms Used Against the Lymantriidae

Pest Name	Biological Agent	Product	Specifics
Autographa californica	b. Viruses	(1) Commercial formulation not known. Agent: AcMNPV	Said to be successful against a range of pests including *Autographa californica.* *(Martignoni, et al., 1982)*
Calliteara pudibunda	b. Viruses	(19) No formulations at present Agent: A single protein *Nuraurelia beta* like virus.	A single protein virus related to *N. Beta* and *Darna* viruses from eggs of *Calliteara pudibunda* in Kent, England (Greenwood & Moore, 1981)
		(20) No formulations at present Agent: DpCPV (a cytoplasmic polyhedrosis virus).	Isolated from *Calliteara (=Dasychira) Pundibunda*, with a high degree of mortality. Shows a wide host range over several insect families.
Dasychira argentata	b. Viruses	(5) No formulations at present. Agent: DaMNPV	Extremely successful NPV against *Dasychira argentata* in Japan, where it destroyed an outbreak of the species (Shibata, 1981)
Dasychira axutha	b. Viruses	(4) No commercial formulation known. Agent: DaCNPV	Recorded from *Dasychira axutha* in China (Chen, et al., 1989)
Dasychira baibarana	a. Bacteria	(9) No commercial formulation known. Agent: tea caterpillar bacterial soft rot	Pathogenic to *Dasychira baibarana* (Dai, 1990)
Dasychira grotei	b. Viruses	(7) No formulations at present. Agent: DgCPV	A cytoplasmic polyhderosis virus (Reoviridae) from China (Wu & Huang, 1986)
Dasychira locuples	b. Viruses	No formulations at present. Agent: DlMNPV	A NPV causing epizootics in *Dasychira locuples* populations in China. The virus is apparently spread in part by flesh flies (Sarcophagidae) (Zhu, et al., 1980); also (Tsia & Ding, 1982)
Dasychira mendosa	b. Viruses	(8) No formulations at present. Agent: DmNPV	A NPV found in *Dasychira mendosa* from India (Rabindra & Subramaniam, 1975)
Dasychira obiquata	c. Protozoa	(11) No formulations at present. Agent: *Nosema lymantriae* from Czech Republic.	A 100% infestation rate of typical infestations from gypsy moth (Solter, et al., 1997)
Dasychira pinicola	c. Protozoa	(8) No formulations at present. Agent: *Microsphridium* sp. (Portugal Isolate).	Heavy response. Low # infected (25%)compared to gypsy moth (Solter, et al., 1997)
		(9) No formulations at present. Agent: *Microsporidium* sp. (Romania Isolate).	Heavy response. Low # of infected (25%) compared to gypsy moth (Soltar, et al., , 1997)
		(11) No formulations at present. Agent: *Nosema lymantriae* from Czech Republic.	80% infection rate. Infections similar to gypsy moth (Solter, et al., 1997)
		(12) No formulations at present. Agent: *Endorecticulatus* sp. from Portugal.	A 46.2% infection rate of infections similar to gypsy moth NOTE: A Generalist (Solter, et al., 1997)

Pest Name	Biological Agent	Product	Specifics
Euproctis chrysorrhoea	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of: *Euproctis chrysorrhoea*. May be combined with sublethal dosages of insecticide for a synergistic effect (Lebrun & Vlayen, 1979). If used alone, apply at rate of 0.4-0.6 kg/ha for formulations containing 16000 IU (Bertucci, 1984)
		(2) Prob. *Dendrobacillin* (Polyakov, 1980).	Highly effective against *Euproctis chrysorrhoea* at a concentration of 2% (Polyakov,1981)
		(3) Dipel EC, Thurcide HP, Foray 76B, 48B Agent: *Bacillus thuringiensis* subs. *kurstaki*, Foray 48F or Condor OF	*Eprotctis chrysorrhoea* at 0.1% (0.32 g/10 liters water) - (Ruelle, et al., 1978). A concentration of 0.15% causes 99% mortality after 14 days and 100% mortality after 3 weeks (Vankova & Novak, 1985) For Foray 76B, apply 8-30 BIU/acre (Abbott Laboratories, 1997); 12-25 BIU/ha (Anon. 1998) Foray 48F or Condor OF augmented with CryIAc Insecticidal Protein at 0.6 to 1 or 5.3 to 1 resulted in significantly increased mortality (Dubois, et al., 1998)
	b. Viruses	(10) No formulations at present. Agent: EcNPV	A NPV found in Yugoslavia from *Euproctis chrysorrhoea* (Sidor, et al., 1975). Also in England, where it was found to have a remarkable host specificity (Kelly, et al., 1988). A dosage of 5 x 10^{12} PIB/ha obtained maximum mortality greater than 90% (Kelly, et al., 1988a)
		(23) No formulations at present. Agent: A *Borrelinavirus sp.*	Does not cause immediate mortality in *Euproctis chrysorrhoea*, but reduces growth, survival, fertility, and offspring vigor. Does not affect normal parasites or predators (Nef, 1975a, see also Sterling, 1989)
	c. Protozoa	(1) Commercial formulation unknown. Agent: *Pleistophora schubergi schubergi* (see Purrini, 1982).	Infects the fat body and the lumen of the intestine (Purrini, 1979)
		(2) Commercial formulation unknown. Agent: *Vairimorpha hyphantriae*	Infective (Simchuk, 1982)
		(3) Commercial formulation unknown. Agent: Unknown *Microsporidium* with characteristics of both *Nosema* and *Thelohania* development.	Infective in the laboratory (Simchuk, 1982)
		(4) Commercial formulation unknown. Agent: *Nosema* sp.	Parasitizing larvae (Sidor, et al., 1980: {urrini, 1979)

Pest Name	Biological Agent	Product	Specifics
	e. Fungi	(1) Commercial formulation not known. Agent: *Empusa aulicae*	Known from Yugoslavia (Sidor, et al., 1975)
		(2) Commercial formulation not known. Agent: *Entomophthora aulicae*	For use against high populations in Poland (Sliwa & Swiezynska, 1978)
		(3) Commercial formulation (?). Agents: *Entomophthora destruens* *Entomophthora thaxteriana* *Entomophthora virulenta*	The first list fungus is from the mosquito *Culix pipiens*, the second and third are from aphids. All three can successfully infect this lepidopterous host in the lab (Krejzova, 1978)
		(4) Mycotrol™-WP (Experimental formulation). Agent: *Beauveria bassiana*	Said to control outbreaks of *Euproctis chrysorrhoea* naturally (Lesko, 1984). The least efficient of three fungi in Poland (42.5%) (Mietkiewski, 1984)
		(5) No commercial formulation known. Agent: *Paecilomyces farinosus*	The most efficient of 3 fungi in trials in Poland (81.2%) (Mietkiewski, 1984)
		(6) No commercial formulation known. Agent: *Verticillium lecantii*	The third of 3 fungi in trials in Poland (81.2%) (Mietkiewski, 1984) This efficiency seems to be borne out by Mietkiewaki in a subsequent paper in 1985, where these fungi were found in nature from dead larvae in proportions as follows: Pf - 46.9%; V1 - 24.6%; and Bb - only 4.2%
Euproctis flava	b. Viruses	(11) No formulations at present. Agent: EfMNPV	A NPV found in China from *Euproctis flava* (Tsia & Ding, 1982) Also reported from Japan (Kawamoto et al., 1977)
Euproctis fraterna	a. Bacteria	(3) Dipel EC, Thurcide HP Agent: *Bacillus thuringiensis* subs. *kurstaki*	*Euproctis fraterna* at 1-3 kg/ha in 100 liters of water (Kumar and Jayaraj, 1978)
Euproctis lunata	a. Bacteria	(7) Dipel EC Agent: *Bacillus thuringiensis* strain HD-1	*Euproctis lunata*, treat at 1120 g/ha, applied to leaves (Dabi, et al., 1980). At 8 mg/litre water for 100% larval mortality with Bactospeine (Rahman & Chaudhury, 1987)
	b. Viruses	(8) No formulations at present. Agent: E1NPV	A NPV found in India from *Euproctis lunata*. Natural incidence was 10-20%, with an incubation period of 6-10 days after feeding with 1.0 x 10^7 polyhedral inclusion bodies/ml (Batta, 1990)
Euproctis melania	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of: *Euproctis melania* when combined with Diflubenzuron for a rapid, synergistic effect (El-Bahrawi, et al., 1979)
Euproctis phaeorrhoea	a. Bacteria	(3) Dipel EC, Thuricide HP Agent: *Bacillus thuringiensis* subs. *kurstaki*	*Euproctis phaeorrhoea* at 0.005% for 1st/2nd instars and at a 0.2% rate for 3rd instars emerging from hibernation (Kneifl, 1977)

Pest Name	Biological Agent	Product	Specifics
Euproctis pseudoconspersa	a. Bacteria	(9) No commercial formulation known. Agent: tea caterpillar bacterial soft rot.	Pathogenic to *Euproctis pseudoconspersa* (Dai, 1990)
	b. Viruses	(13) No formulations at present. Agent: EpNPV	A NPV found in China from *Euproctis pseudoconspersa* (Zhang, 1986). In spray formulations, it gives 70-80% control
	e. Fungi	(7) Commercial formulation (?). Agent: *Metarhizium anisopliae strain Ma 83*	Application results in a mortality of 77.4% (Fan, et al., 1988)
Euproctis scintillans	b. Viruses	(1) Biocontrol-1 Agent: OpMNPV (???)	A NPV was found in *Euproctis scintillans* in China (Shi, et al., 1984)
Euproctis similis	a. Bacteria	(5) Entobakterin Agent: *Bacillus thuringiensis* var. *galleriae* (6) Bitoxibacillin Agent: *Bacillus thuringiensis (BTB-202)* (10) No commercial formulation known. Agent: *Enterobacter* sp.	For control of: *Euproctis similis.* Adding Trichlorphon may be necessary (Stus', 1980) For control of: *Euproctis similis.* Mortality approaches 100% after 7 days (Stus', 1979) Pathogenic to *Euproctis similis* in the lab from Japan (Tomita & Iwashita, 1987)
	b. Viruses	(21) No formulations at present. Agent: *Baculovirus* subgroup A (24) No formulations at present. Agent: *Borrelinavirus euproctis*	Larval mortality in *Euproctos similis* is 50% after 10 days, and 93% later on (Chu, et al., 1975). A NPV was also isolated later (Zhu & Peng, 1984) In mixed infestations with *Nosema* prob. *kovacevici* in nuclei of the adipose tissue of *Euproctis similis* (Purrini, 1979)
	c. Protozoa	(5) Commercial formulation unknown. Agent: *Pleistophora carpocapsae* (6) Commercial formulation unknown. Agent: *Pleistophora schubergi* (7) Commercial formulation unknown. Agent: *Nosema* prob. *kovacevici*	Experimentally infested the larvae (Simchuk, 1979) Causes 59% infestation of the intestinal cavity of larvae of the host of which most are 5th instar (Purrini, 1979) Is combined with a NPV, *Borrelinavirus,* in mixed infestations. Infests the fat body. (Purrini, 1979)
	e. Fungi	(8) No commercial formulation. Agent: *Beauveria* sp. (9) No commercial formulation. Agent: *Metarhizium* sp.	Found in Germany. See Purrini, 1979. There will be a *Beauveria bassiana* formulation, Mycotrol--WP available in the USA (Ferguson, 1995) See Purrini, 1979
Euproctis subnotata	b. Viruses	(14) No formulations at present. Agent: EsNPV	A NPV found in India from *Euproctis subnotata* larvae (Patil & Kulkarni, 1990)
Euproctis sp.	a. Bacteria	(8) No commercial formulations known. Agent: *Bacillus subtilis*	Pathogenic to *Euproctis* sp. (Nayak & Srivastava, 1978)

Pest Name	Biological Agent	Product	Specifics
Heteronygmia dissimilis	e. Fungi	(10) No commercial formulation. Agent: *Paecilomyces farinosus*	Found in Tanzania, where it attacks the pupae in epidemic numbers (Schabel, et al., 1988)
Laelia coenosa	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of *Laelia coenosa* at concentrations of 200 g Bt plus 50 g DDVP (Diclorvos) at hatching peak of first generation or 150 g Bt if at the end of the peak hatching period (Li, 1987a)
	e. Fungi	(1) No commercial formulation. Agent: *Paecilomyces* sp.	Found in China (Li, 1987)
Leucoma salicis	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of : *Leucoma salicis* (Maksymov, 1980)
		(3) Dipel EC, Thurcide HP, Foray 76B, 48B Agent: *Bacillus thuringiensis* subs. *kurstaki*	Causes 82.1% larval mortality in *Leucoma salicis after 120 hours (Szalay-Marzso, et al., 1981)* *For Foray 76B apply 6-16 BIU/acre (Abbott Laboratories, 1997)*
		(4) Commercial formulation not known. Agent: *Bacillus thuringiensis* strain 6KD	For control of *Leucoma salicis. Causes* 100% larval mortality in 2-6 days (Kuzmanova, et al., 1980)
	b. Viruses	(18) No formulations at present. Agent: LaMNPV (A Baculovirus)	A NPV found in Bulgaria from *Leucoma salicis* (Antanasov, 1982 & 1983). Also reported from Poland and many European countries (Ziemnicka, 1976). The Polish isolate is very infective and has been tested (Lameris, et al., 1985). One is also reported from China (Tsai, et al., 1978; Zhu & Peng, 1984). This one is reportedly passed on to the 2nd generation (Chen, 1984).
		(23) No formulations at present. Agent: A *Borrelinavirus* sp.	Does not cause immediate mortality in *Leucoma salicis*, but reduces growth, survival, fertility, and offspring vigor. Does not affect parasites or predators (Nef, 1975a, see also Sterling, 1989)
		(31) No formulations known. Agent: LsCPV	Identified as a Cyctoplasmic polyhedrosis virus pathogenic to *Leucoma salicis* (Ziemnicka, 1976)
	d. Nematodes	(1) Commercial formulation not known. Agent: *Heterorhabditis heliothidis*	Causes substantial larval mortality in *Leucoma salicis.* Pupae and adults are also killed (Finney & Bennett, 1984)
	e. Fungi	(12) No commercial formulation. Agent: *Paecilomyces* sp.	High mortality in overwintering larvae (Wagner & Leonard, 1980)
		(13) No commercial formulation. Agent: *Hirsutella gigantea*	High mortality in overwintering larvae (Wagner & Leonard, 1980)
		(14) No commercial formulation. Agent: *Fusarium* sp.	Complete mortality of larvae (Ogarkov & Ogarkova, 1979)
		(4) Mycotrol (?) Agent: Beauveria sp.	Said to reduce some outbreaks (Humphreys, 1984)

Pest Name	Biological Agent	Product	Specifics
Leucoma wiltshirei	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of *Leucoma wiltshirei* (Adeli, 1980; Abai, 1981)
Lymantria dispar	a. Bacteria	(3) Dipel EC, Thurcide HP, 48LV, or Foray 76B, 48B, F Agent: *Bacillus thuringiensis* subs. *kurstaki*	For suppression of *Lymantria dispar*, dosage is one application at 24 BIU per acre, but this may go to 30 or 36 BIU/Acre and an additional treatment at a lower dosage of 16 BIU/Acre may be applied later. For eradication, typical dosage is 24 BIU/Acre, applied 2-3 times. (Anon., 1995) This treatment is the primary, and most successful eradication treatment employed by the USDA. Not as effective on oak trees due to tannin inhibition (Appel & Schultz) Varabily effective on aspen depending on concentration of tannins and phenolic glycosides (Hwang, et al., 1995)
			For Foray 76B, apply 8-40 BIU/acre (Abbott Laboratories, 1997); 25-60 BIU/ha (Anon. 1998)
		(12) No commercial formulation at present. Agent: CryIA(a) and (c)from BT	Lethality enhanced by spores of *Bacillus cereus, B. megaterium, B. subtilis, and a B. thuringiensis* noncrystalliferous strain (Dubois & Dean, 1995). Also enhanced by vegetative cells of *Klebsiella sp., K. pneumonia, Erwinia amylovora, E. Rubrifaciens, Pseudomonas fluroescens, Xanthomonas* sp., *X. campestris, Actinomyces* sp., *Corynebacterium* sp., *Flavobacterium* sp. and Escherichia coli bacteria (Dubois & Dean, 1995)
	b. Viruses	(9) No formulations at present. Agent: DpCPV	A cytoplasmic polyhedrosis virus from the unrelated Pine moth (*Dendrolimus pini*) which also develops intensively in *Lymantria dispar* (Golosova, 1986)
		(15) Gypchek (Disparvirus - Canada Agent: LdMNPV	A NPV formulated by the Forest Service and APHIS in limited quantities for *Lymantria dispar.* It is a *Baculovirus.* It is aerially applied at the rate of 2×10^{11} to 1×10^{12} occusion bodies in 1.0 gal. of spray mix (water, sunscreen, molasses)/Acre. Two applications, 3 days apart, are recommended during first and second instars and when oak foliage is 25% expanded (Anon., 1995)
			This is the only viral agent currently used for control/suppression of Gypsy Moth in the United States
			When combined with a 3% azadirachtin formulation, a 30-40% increase in larval mortality results (Cook, et al., 1996)

Pest Name	Biological Agent	Product	Specifics
			Adding 0.1% Blankophor BBH enhanced with 1/10 standard Gypchek rate results in high and quick mortality (90%) (Webb, et al., 1996; also see Cunningham, et al., 1997) Another brightener, Tinopal LFW, also enhances viral activity (Shapiro & Argauer, 1995; Sheppard & Shapiro, 1994) Effect enhanced by the addition of the fungus *Entomophaga maimaiga* (Smitley, et al., 1995)
	c. Protozoa	(8) No formulations at present. Agent: Microsphridium sp. (Portugal Isolate)	Heavy infestations (83.1%) found on gypsy moth in Portugal (Solter, et al., 1997)
		(9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate)	Heavy infestations (90.9%)found on gypsy moth in Romania (Solter, et al., 1997)
		(10) No formulations at present. Agent: Microsporidium sp. (Slovakia Isolate)	Heavy infestations (93.8%) found on gypsy moth in Slovakia. (Solter, et al., 1997)
		(11) No formulations at present. Agent: Nosema lymantriae	Heavy infestations (95.2%) found on gypsy moth in the Czech Republic (Solter, et al., 1997)
		(12) No formulations at present. Agent: Endorecticulatus sp. from Portugal	Moderate infestations (51.2%) found on gypsy moth in Portugal. NOTE: A generalist (Solter, et al., 1997)
	e. Fungi	(17) No commercial formulation. Agent: *Entomophaga maimaiga*	Rapid and quick spreading infestations cause 20 to 99% mortality rates. Works well with NPV to control populations (Smitley, et al., 1995)
			Inoculative releases include clearing 1m area of soil around host and spreading spore-infected soil (937 spores/gram) on this, covering with leaves <u>OR</u> inoculating a liquid culture (523 protoplasts/larva)into 3rd instars, with release of 15 larvae per host within 2-3 days (Smitley, et al., 1995)
			Additional research is critically needed (Reardon & Hajek, 1998)

Pest Name	Biological Agent	Product	Specifics
Lymantria mathura	b. Viruses	(16) No formulations at present. Agent: LmMNPV	A NPV found in China from *Lymantria mathura* (Tsia & Ding, 1982)
	c. Protozoa	(9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate)	Infections similar to gypsy moth at 25% omfected (Solter, et al., 1997)
		(11) No formulations at present. Agent: Nosema lymantriae from Czech Republic.	66% infection rate of atypical developmental forms (Solter, et al., 1997)
		(12) No formulations at present. Agent: Endorecticulatus sp. from Portugal.	Almost negligible infection rate. NOTE: a generalist (Solter, et al., 1997)
Lymantria monacha	a. Bacteria	(3) Dipel EC, Thurcide HP, Agent: *Bacillus thuringiensis* subs. *kurstaki*	*Lymantria monacha* is treated at 1.5 kg/ha, This causes 100% mortality after 6 days. The addition of sublethal quantities of Diflubenzuron will result in 100% mortality sooner (Fankhanel, et al., 1987) Foray 48B, 76B, Thuricide 48LV. Foray 48B and 76B are presently being used to control this pest in Europe (Fusco persc. comm). The suggested dose is 50 Blu/ha (Anon. 1998)
		(6) Bitoxibacillin Agent: *Bacillus thuringiensis* (BTB - 202)	Treat for *Lymantria monacha* at a rate of 1.5 kg/ha. Mortality reaches 100% after 10-12 days. Sublethal quantities of Diflubenzuron causes greater mortality sooner (Fankhanel, et al., 1987)
		(7) Dipel Agent: *Bacillus thuringiensis* strain HD-1	Treat for *Lynantria monacha* at 0.15 kg/ha of a combination of NPV and Dipel. This will induce an earlier mortality onset of greater than 90% (Altenkirch, et al., 1986)
	b. Viruses	(22) No formulations at present. Agent: A *Baculovirus* sp.	A NPV of *Lymantria monacha*. A mortality rate of 82% is achievable in spruce, but much less than in pine stands, where BT preparations show a better mortality rate (Glowacka-Pilot, 1985)
Lymantria xylina	b. Viruses	(17) No formulations at present. Agent: LxNPV	A NPV found in China from *Lymantria xylina* (Chang, et al., 1987)
	c. Fungi	(15) Nycitrik --WP (experimental formulation). Agent: *Beuveria bassiana*	A formulation is used in Tawain to control this species (Chang, 1991)
Ocnerogyia amanda	a. Bacteria	(7) Dipel Agent: *Bacillus thuringiensis* strain HD-1	Treat *Ocnerogyia amanda* with a 3.5% WP of Bactospeine to obtain complete kill of 1st and 2nd instar larvae (Abai & Faseli, 1986)

Pest Name	Biological Agent	Product	Specifics
Orgyia antiqua	a. Bacteria	(1) Thurcide, Foray Agent: *Bacillus thuringiensis*	For control of *Orgyia antiqua* at concentrations of 0.1 - 0.15% (about 1.5 kg/ha). Very good results can be obtained with 0.05% BT mixed with 0.02 phosalone (about 0.3 litres/ha) (Niemczyk, 1980) *Orgyia antiqua* at 0.05% and 0.02% cglordimeform (Lipa, et al., 1977). With one gram Permethrin/ha, causes 92% larval mortality (Svestka & Vankova, 1978) For control of *orgyia antiqua* at 50 BIU/ha (Anon. 1998).
	b. Viruses	(25) No formulations at present. Agent: OaNPV	From China, toxic to larvae of *Orgyka antigua* (He & Zhang, 1990)
	c. Protozoa	(8) No formulations at present. Agent: Microsporidium sp (Portugal Isolate). (9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate) (11) No formulations at present. Agent: Nosema lymantriae from Czech Republic.	Heavy response. Low # infected compared to gypsy Moth (Solter, et al., 1997) Very heavy. 100% infected compared to gypsy moth (Solter, et al., 1997) Hypersensitive with 100% infection rate, infections typical and atypical of gypsy moth produced (Solter, et al., 1997)
Orgyia ericae	b. Viruses	(27) No formulations at present. Agent: OeNPV	A preliminary study only of NPV of *Orgyia ericae* (Zhang, 1991)
Orgyia definita	c. Protozoa	(9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate) (11) No formulations at present. Agent: Nosema lymantriae from Czech Republic.	A 70% infection rate, but few spores produced and atypical development (Solter, et al., 1997) Infection rate 84.6%, infections typical of gypsy moth (Solter, et al., 1997)
Orgyia gonostigma	a. Bacteria	(3) Dipel (Thurcide HP) Agent: *Bacillus thuringiensis* subs. *kurstaki* (5) Entobakterin Agent: *Bacillus thuringlensis* var. *galleriae*	For control of *Orgyia gonostigma* at 0.15% applied at the rate of 100 litres/decare For *Orgyia gonostigma*, apply at 30 million spores/g at 0.5% (5 kg/ha) plus tricholrphon at 0.3 kg or phosalone at 0.2 kg (Sevryukova, 1979)

Pest Name	Biological Agent	Product	Specifics
Orgyia leucostigma	b. Viruses	(2) Virtuss Agent: O1NPV	For *Orgyia leucostigma.* Infests 100% of larvae after 5 weeks and spreads strongly (West, et al., 1989)
	c. Protozoa	(8) No formulations at present. Agent: Microsporidium sp. (Portugal Isolate).	Heavy response. Low numbers infected compared to gypsy moth (Solter, et al., 1997)
		(10) No formulations at present. Agent: Microsporidium sp. (Slovakia Isolate).	Atypical developmental forms, but infections (82%) similar to gypsy moth (Solter, et al., 1997)
		(9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate).	Infections moderately high (60%); similar to gypsy moth (Solter, et al., 1997)
		(11) No formulations at present. Agent: Nosema lymantriae from Czech Republic.	A 90% infestation rate. Infestations similar to gypsy moth (Solter, et al., 1997)
	e. Fungi	(16) No commercial formulation. Agent: *Fusarium solani*	Found in India on this species (Maharaj & Patil, 1986)
Orgyia postica	b. Viruses	(1) Biocontrol-1 Agent: Opmnpv	Has infected *Orgyia postica* in lab trials (Su, 1986a). A NPV (the same, ???) was found in this species in China (Shi, et al., 1984)
Orgyia prisca	a. Bacteria	(2) Prob. *Dendrobacillin (Polyakov, 1980)*	For control of *Orgyia prisca* (Akhmedov, 1982)
Orgyia pseudotsugata	a. Bacteria	(1) Thuricide Agent: *Bacillus thuringiensis*	For control of *Orgyia pseudotsugata* when mixed with molasses and applied at the rate of 9.5 litres/ha (Anon., 1980)
		(3) Foray 76B Agent: *Bacillus thuringiensis* subs. *kurstaki*	Apply 8-30 BIU/acre (Abbott Laboratories, 1997)
	b. Viruses	(1) Biocontrol-1 Agent: Opmnpv	Registered for control of *Orgyia pseudotsugata* (Martignoni, et al., 1982; Anon., 1980). This NPV apparently can survive for long periods in the soil and was still infective after 40 years (at roughly, 45 polyhedral inclusions per cm^2 in one study (Thompson, et al., 1981). The UV absorbers Tinopal DCS (a stilbene fluorescent whitening agent) and Raymix powder (a lignosulfonate), when added, give protection to the virus (Martignoni & Iwai, 1985). The virus can spread into adjoining areas through natural means, thus helping to control the lymantriid populations it comes into contact with (Otvos, et al., 1987)

Pest Name	Biological Agent	Product	Specifics
		(3) Commercial formulation not known. Agnet: AcMNPV	Said to be successful against a range of pests including *Orgyia pseudotsugata* (Martignoni, et al., 1982)
		(29) No formulations Agent: OpNPBV	Identified as a *Baculovirus* pathogenic to *Orgyia pseudotsugata* (Schafer, et al., 1979)
		(30) No formulations Agent: OpNPSV	Identified as a *Baculovirus* pathogenic to *Orgyia pseudotsugata* (Schafer, et al., 1979)
	c. Protozoa	(8) No formulations at present. Agent: Microsporidium sp (Portugal Isolate).	Atypical developmental forms but infections similar to gypsy moth (Solter, 1997)
		(9) No formulations at present. Agent: Microsporidium sp. (Romania Isolate).	High early mortality (100%) & hypersensitive, atypical developmental forms (Solter, et al., 1997)
		(11) No formulations at present. Agent: Nosema lymantriae from Czech Republic.	Hypersensitive with 100% infection rate, infections typical and atypical of gypsy moth produced (Solter, et al., 1997)
		(12) No formulations at present. Agent: Endorecticulatus sp. from Portugal.	A 75% infection rate of infections similar to gypsy moth (Solter, et al., 1997)
Orgyla thyellina	a. Bacteria	(11)Foray 48B Agent: *Bacillus thuringiensis* subs. *kurstaki*	For eradication of *Orgyia thyellina in New Zealand (OEG EIS, 1996)*
	b. Viruses	(26) No formulations known. Agent: OtNPV	Causes mortality to all instars of *Orgyia thyellina* (Sato, 1979)
		(28) No formulations at present. Agent: OtCPV	Causes mortality to all instars of *Orgyia thyellina* (Sato, 1979)

The following table lists those Juvenile Hormone Mimics and Insect Growth Regulators which have been found to be useful for the Lymantriidae.

It should be remembered that nongenetic resistance may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action. (Appel & Schultz, 1994) Currently, adverse reaction against JH or IGR has not been documented.

TABLE B. Table of Juvenile Hormone (JH) Mimics or Insect Growth Regulators in the Lymantriidae

Pest Name	Formulation	Specifics
Euproctis chrysorrhoea	(1) Diflubenzuron (Dimilin)	Results in 100% mortality for all 3 generations of *Euproctis chrysorrhoea* (Georgevitis, 1979). ULV applications give satisfactory control (Grill & Caldumbide, 1987). If used in conjunction with an oil surfactant (Atplus 412 in commercial formulation Atatop), the insecticide may be used at half normal dosage for *Euproctis chrysorrhoea* (Schering, 1987).
	(3) Ethyl 11-chloro-3,7,11-trimethyl-2-dodecenoate Ethyl 3,7,11-trimethyl-2,4-do decadienoate	These two juvenile hormone analogues are effective against *Euproctis chrysorrhoea* at the rate of 0.5% emulsion. This treatment always prevented adult emergence. Larval parasites emerged from treated hosts in the same numbers as untreated hosts, hence parasites are spared any mortality (Novak & Sehnal, 1973).
Euproctis icilia	(7) Penfluron	Use 0.01% to produce 100% mortality in *Euproctis icilia* (Khan & Srivastava, 1990)
Euproctis lunata	(1) Diflubenzuron (Dimilin)	Use as a full cover spray at 0.04% for *Euproctis lunata* to obtain 100% mortality 16 days after application (Rahman & Chaudhury, 1987)
	(9) Triflumuron	Use Aysystin at 0.04% for control of *Euproctis lunata* to obtain 100% mortality 8 days after application (Rahman & Chaudhury, 1987)
Euproctis melania	(1) Diflubenzuron (Dimilin)	This formulation is slow in action for *Euproctis melania* (El-Bahrawi, et al., 1979)
Euproctis taiwana	(8) Teflubenzuron	Use CME-134 at the rate of 0.1 to 0.3 ug a.i./ml. Mortality should be 96.4 to 100% for *Euproctis taiwana* (Su,1985)
Leucoma candida	(1) Diflubenzuron (Dimilin)	Use as a full cover spray at 150 to 300 g/ha a.i. of 25% Dimilin III to obtain 91.7% mortality of *Leucoma candida* (Zhang, et al., 1987)
Leucoma salicis	(1) Diflubenzuron (Dimilin)	Use as a full-cover spray for *Leucosa salicis* (Vasic, 1980)
	(5) Hydroprene	Use hydroprene at 0.1% for *Leucoma salicis* to obtain 83% control of the susceptible stages (Varjas, 1975)
Leucoma wiltshirei	(1) Diflubenzuron (Dimilin)	Results in 100% mortality for all 3 generations of *Leucoma wiltshirei* (Abai, 1981). ULV applications give satisfactory control (Grill & Caldumbide, 1987)
Lymantria dispar	(1) Diflubenzuron (Dimilin)	This is a commonly used insect growth regulator for suppression or eradication of *Lymantria dispar*. Two formulations are available; Dimilin 25W (to be phased out) and Dilmilin 4L. Both aerial and ground applications are used. Aerial application is at the rate of 0.25 to 1.00 ounces a.i. in 0.5-2.5 gallons of spray volume/acre. No more than two applications per year are allowable. Typically, aerial application is at the rate of 0.5 ounces a.i. in 0.75 to 1.00 gallon spray volume/acre, twice for eradication purposes and once for suppression purposes. (Anon., 1995)

Pest Name	Formulation	Specifics
	(2) Epofenonane	Is apparently of value in the suppression of *Lymantria dispar* (Frischknecht & Muller, 1976)
	(4) Fenoxycarb	Treatment with fenoxycarb (Insegar 25% WP) or its derivative NKI-35120, which is more effective, results in control of *Lymantria dispar* (Varjas, 1992)
	(5) Hydroprene (6) Methoprene	Is apparently effective against *Lymantria dispar* and does not affect the larval parasite, *Apanteles melanoscelus* (Granett, et al., 1975) Use methoprene at an emulsion spray rate equivalent to 0.5 Kg/ha a.i. for 100% inhibition of adult emergence of *Lymantria dispar*. (Sehnal, et al., 1976)
Lymantria monacha	(1) Diflubenzuron (Dimilin) (6) Methoprene	Use also as a full-cover spray for *Lymantria monacha* (Bychawska, 1986). Use at 2.5-3 litres/ha of a mixture containing 0.16-0.17 litres Dimilin and 2-2.5 litres of oil propellant. This will obtain mortalities of 90-100% by 15 days after application (Sliwa, 1984). Grijpma, 1985, states that 300g WP25 in 30 litres water/ha in May, gives complete control. Use as a full-cover spray for *Lymantria monacha* at the rate of 200 g/ha (Fankhanel, et al., 1987). Or apply aerially at 0.16 -0.17 litres conc. plus 2.5 litres diesel oil with ULV to obtain 95-100% mortality (Sliwa, 1985). Use methoprene at an emulsion spray rate equivalent to 0.5 Kg/ha a.i. for 100% inhibition of adult emergence of *Lymantria monacha* (Sehnal, et al., 1976).
Ocnerogyia amanda	(1) Diflubenzuron (Dimilin)	Results in complete kill of 1st and 2nd instar larva of *Ocnerogyia amanda*, with applications of a 25% WP formulation (Abai & Faseli, 1986).
Orgyia antiqua	(1) Diflubenzuron (Dimilin)	This formulation is unsatisfactory for *Orgyia antiqua* (Dadej, 1979).
Orgyia postica	(8) Teflubenzuron	Use CME-134 at the rate of 0.1 to 0.3 ug a.i./ml. Mortality should be 96.4 to 100% for *Orgyia postica* (Su, 1985)
Orgyia pseudotsugata	(1) Diflubenzuron (Dimilin)	Use as a full-cover spray for *Lymantria monacha* at the rate of 200 g/ha (Fankhanel, et al., 1987). Or apply aerially at 0.16-0.17 litres conc. plus 2.5 litres diesel oil with ULV to obtain 95-100% mortality (Sliwa, 1985).

The following table gives those plant extracts which have been successfully used against the Lymantriidae.

It should be remembered that nongenetic resistance may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action (Appel & Schultz, 1994). Currently, adverse reactions with Plant Extracts have not been documented. Commercial formulations of Azadirachtin (a neem extract) are available which would probably work better than most of the crude extracts cited in the references. For example, commercial Neem extracts may be found at:

<http://www.plasmaneem.com/feedback.htm>

TABLE C. Plant Extracts Successfully Employed Against the Lymantriidae

Pest Name	Plant Extract	Specifics
Euproctis chrysorrhoea	(1) Commercial formulation not known. Agent: Coniferous vegetation *(Resinous substances)*	Extracts of resinous substances on apricot leaves kill 2nd instar larvae (Semakov, 1990).
Euproctis fraterna	(1) Commercial formulation not known. Agent: *Azadirachta indica* (Neem tree) (2) Commercial formulation not known. Agent: *Pongamia glabra*	Acetone leaf extracts at a conc. of 1000 ppm creates larval-pupal intermediates and deformed adults (Sridhar & Chetty, 1989). Acetone leaf extracts at a conc. of 1000 ppm creates larval-pupal intermediates and deformed adults (Sridhar & Chetty, 1989).
Euproctis lunata	(1) Commercial formulation not known. Agent: Mucuna pruriens	Spray extracts of the roots of this plant are toxic, with an LC50 after 24 hrs for 4th instar larvae (Srivastava, et al., 1983).
Euproctis scintillans	(1) Commercial formulation not known. Agent: *Erythrina indica* (2) Commercial formulation not known. Agent: Delonix regia	An ether extract of the seeds at 0.5% conc. resulted in up to 91% larval mortality following treatment (Senthamizhselvan & Muthukrishnan, 1992). An ether extract of the flowers at 0.5% conc. results in up to 91% larval mortality following treatment (Senthamizhselvan & Muthukrishnan, 1992).
Heteronygmia dissimilis	(1) Commercial formulation not known. *Agent: Azadirachta indica* (Neem tree)	Crude aqueous extracts of seed kernal at 1% conc. from neem provides complete protection from all instars, which die of starvation (Rwamputa & Schabel, 1989).
Lymantria dispar	(1) Prob. Azatin *Agent: Azadirachta indica* (Neem tree) (2) Golden Noctual Spray Oil Agent: Soybean oil	Exposure to 3% azadirachtin causes a 15% larval mortality and a 30-40% mortality when combined with Gypchek (Cook, et al., 1996) For egg stage. (Pers. Comm., Victor Mastro)

The following table gives those known pheromones for the Lymantriidae, with an outline of details for their use from the literature.

It should be remembered that nongenetic resistance may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action (Appel & Schultz, 1994). Currently, adverse reactions against Pheromones in the Lymantriidae are not documented.

TABLE D. Known Pheromones in the Lymantriidae and Their Current Use

Pest Name	Pheromone	Specifics
Dashcyira plagiata	(3) Commercial formulations not known Agent: Synthetic pheromone of (Z)-6-henciconsen-11-one	This pheromone may be used to disrupt populations of *Dasychira plagiata* at a rate of about 92-100% disruption (Grant, 1978)
Leucoma salicis	(1) Formulation not known Agent: Pheromone	In theory, mass trapping against the Satin moth can be augmented by the addition of its baculovirus, LsMNPV, especially the isolate from Poland. This treatment does not immediately kill the moth and instead relies on an open trap that exposed moths can leave and thus infect others in the population. (Lameris, et al., 1985)
Lymantria dispar	(2) Disparlure Agent: Synthetic pheromone of (+)cis-7,8epo-2Me-18Hy	The use of <u>mass trapping</u> against low population densities is one of the approved methods of eradication given in the USDA Gypsy Moth Manual. To do this, increase trapping densities in the core area up to 9-10 traps per acre (6,440/sq mi). These figures approach the optimum for trap efficiency of approximately 26 feet (8 meters) apart (Bednyi, 1978). At this trapping density, 100% of males of Gypsy moth will be trapped before mating occurs.
		The effect of such trapping on other species has not been studied, but as with gypsy moth, it is assumed that all males must be trapped before they can mate with a female. Undoubtedly, species with actively flying females would be harder to eradicate with this technique.
		The <u>male confusion</u> technique has been approved for field use in the U.S. It can be employed against low populations (less than 10 egg masses per acre). Disparlure is dispersed throughout the infested area in the air and may be supplemented on the ground. Treatments are applied 5 days after male pupation occurs and again 14 days after the first application. APHIS methods development (now PPL) or the Forest Service may be consulted for application rates. (Anon., 1990)
		A note of caution in this technique is possible accommodation to the pheromone. It has been said that for gypsy moth, a relatively high concentration of Disparlure applied all at once may result in a brief, violent response, and then cease as the male becomes accustomized to the pheromone. Such an exposure results in a situation where the attractant has no effect at all (Il'ichev, 1981) However, this observation may not be accurate. It is also known that males stimulated by pheromone are capable of using a number of different additional stimuli to initiate and terminate short-range sexual behavior patterns, thus defeating the purpose of disruption. Such males apparently may not respond to pheromone traps, but can very efficiently locate and mate with female moths (Richerson, 1977)

Pest Name	Pheromone	Specifics
Lymantria monacha	(2) Disparlure Agent: Synthetic pheromone of (+)cis-7,8-epo-2Me-18Hy	Disparlure may also be used to disrupt populations of *Lymantria monacha*, using pheromone traps (Cwiklinski, 1989; Altenkirch, 1985). Sticky boards with disparlure catch males of up to 2,000 - 3,000 (at which point an outbreak is likely to occur) (Schmutzenhofer, 1986). The effective range of a trap is about 50 meters for this species (Boness, et al., 1974). Aerial spraying of 20 gm disparlure per ha disrupts mating in spray year and year following, with consequent population decline. (Schmutzenhofer, 1986)
Lymantria obfuscata	(2) Disparlure Agent: Synthetic pheromone of (+)cis-7,8-epo-2Me-18Hy	The same information as given for *Lymantria monacha* also applies to *Lymantria obfuscata* (Masoodi, et al., 1990)
Orgyia leucostigma	(3) Commercial formulations not known Agent: Synthetic pheromone of (Z)-6-heneiconsen-11-one	This pheromone may be used to disrupt populations of *Orgyia leucostigma* at a rate of 96-100% disruption (Grant, 1978)
Orgyia pseudotsugata	(3) Commercial formulations not known Agent: Synthetic pheromone of (Z)-6-heneiconsen-11-one	Mass trapping may also be employed against this pest. To augment the effect, 50 ml a.i. of: Diflubenzuron (@ 5% wt[AI] vol. in petroleum solvent), fenvalerate (@ 30% in the same solvent), diazinon (@ 17% in solvent), malathion (@ 50% in xylene), or carbaryl (@ 42% in water). May be applied to the sticker on the trap floor. (Sower & Shorb, 1985) For use against high populations. Release hollow fibres with the pheromone by air, at the rate of 8g pheromone/acre (71% control) or at 25 g pheromone/acre (81% control). (Sower, et al., 1983) Use sprayable polyvinal chloride beads with pheromone impregnated at the rate of 72 g/ha for total mating disruption by ground or air (Hulme & Gray, 1994)
Orgyia thyellina	(4) Commercial formulations not known Agent: Synthetic pheromone of (Z)-6-heneicosen-11-one	Employed as a high density mass trapping technique in New Zealand at a core rate of 25,900 sq/mi and a buffer rate of 6,475 sq/mi. The last rate is equal to the eradication rate for low populations of gypsy moth. Note that *Orghia thyellina* females can fly and the NZ population was unknown, so trapping was not relied on as an eradication technique. (OEG EIS, 1996)

The following table lists the known parasites and predators of the Lymantriidae. They are given under the lymantriid species involved, with such notes from the literature that are available.

Note that parasites of the genus *Hyposoter* may need other parasites in the host before they can complete development.

TABLE E. Parasites and Predators of the Lymantriidae

Pest Species	Parasites/Predators	Notes
Arctornis alba	a. *Trichogramma chilonis*	An overwintering egg parasite (Xia, et al., 1982).
Calliteara cerigoides	a. *Mescomys orientalis*	An egg parasite with an effective parasitic rate of 78% when combined with the parasite below (Messer, et al., 1992).
	b. *Tyndarichus navae*	An egg parasite (Messer, et al., 1992). However, this could also be a hyperparasite (Fuester, ARS, pers.comm.)
Callateara argentata	a. *Exorista japonica*	A tachinid parasite from Japan (Shima, 1996).
Calliteara pudibunda	a. *Rhacodinella apicata*	A larval parasite (Karczewski, 1978).
Dasychira sp.	a. *Monodontomerus dentipes*	A larval/pupal parasite in more than 99% of host population (Wali & Chaudhry, 1979).
Dasychira abietis	a. *Telenomus tetratomus*	Found frequently on eggs of this host in Europe (Anderson & Kaya, 1976).
	b. *Trichogramma dendrolimi*	Found frequently on eggs of this host in Europe (Anderson & Kaya, 1976).
Dasychira axutha	a. *Telenomus dasychiri*	An egg parasite (Chen & Wu, 1981).
Dasychira baibarana	a. *Trichogramma chilonis*	An overwintering egg parasite (Xia, et al., 1982).
	b. *Trichogramma dendrolimi*	An overwintering egg parasite (Xia, et al., 1982).
Dasychira glaucinoptera	a. *Triochogramma chilnnis*	An overwintering egg parasite (Xia, et al., 1982).
	b. *Trichogramma dendrolimi*	An overwintering egg parasite (Xia, et al., 1982).
Dasychira horsfieldi	a. *Henicospilus dasychirae*	An ichneumonid larval parasite (?) from Ceylon (Beeson & Chatterjee, 1935)
Dasychira lunulata	a. *Carcelia amphion*	A tachinid parasite from Japan (Scheafer & Shima, 1981)
	b. *Carcelia gnava*	A tachinid parasite from Japan (Scheafer & Shima, 1981)
Dasychira mendosa	a. *Tachina (Tricholyga) sp.*	A larval parasite (Mehra & Sah, 1974).
	b. *Carcelia spp*	Two species of larval parasites are known (Mehra & Sah, 1974).
	c. *Drino sp.*	A larval parasite (Mehra, & Sah, 1974).
	d. *Sisyropa formosa*	(Mehra & Sah, 1974).
	e. *Henicospilus rufus*	An ichneumonid larval parasite(?) from India, Malaysia, Indonesia, China and Africa (Beeson & Chatterjee, 1935).

Pest Species	Parasites/Predators	Notes
Dasychira plagiata	a. *Telenomus bifidus*	A 2 to 6% rate of egg parasitism for this host in North America (Anderson & Kaya, 1976).
	b. *Trichogramma minutum*	A 2 to 6% rate of egg parasitism for this host in North America (Anderson & Kaya, 1976).
Euproctis aethiopica	a. *Glyptapanteles africanus*	A braconid larvalparasite from Africa (Walker, 1994).
Euproctis chrysorrhoea	a. *Alsomyia nidicola*	A tachinid parasite of mature larvae from Turkey (Oncuer, et al., 1977) and of pupae also (Oncuer, et al., 1978).
	b. *Aprostocetus xanthopus = (Tetrastichus mokrzeckii)*	A parasitoid (Graham, 1991).
	c. *Apanteles inclusus*	A parasite from China (also known from India) (You, et al., 1983). A larval parasite. Full grown larvae may emerge from host prepupae or pupae (Fuester, ARS, pers. comm.)
	d. *Argyrophylax sp.*	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).
	e. *Asolcus turkarkandas*	A recently described egg parasite, with a 77.6% rate of parasitism (Oncuer, et al., 1982).
	f. *Blondelia nigripes*	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).
	g. *Brachymeria sp.*	A chalcidid parasite of the pupa mostly (Oncuer, et al., 1978).
	h. *Calosoma sycophanta*	A carabid predator from Italy capable of decimating entire populations of the host (Delrio & Luciano, 1985).
	I. *Carcelia laxifrons*	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).
	j. *Compsilura concinnata*	A tachinid parasite of mature larvae from Turkey, (Oncuer, et al., 1977).
	k. *Dermestes lardarius*	A dermestid predator of this host (Oncuer, et al., 1978).
	l. *Dibrachys cavus*	Associated with this hoat (Kusevska, 1977). A facultative hyperparasite (Fuester, ARS, pers. comm.)
	m. *Dibrachys fuscicornis*	A primary and also a secondary parasite of tachinid parasites of this host (Kusevska, 1977).
	n. *Echinomyia praeceps*	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).

Pest Species	Parasites/Predators	Notes
	o. Eupteromalus peregrinus	A hymenopterous parasite of young larvae from Germany (Vater, 1980) and Turkey (Oncuer, et al., 1977).
	p. Exorista larvarum	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).
	q. Exorista segregata	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976).
	r. Masicera sphingivora	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976) with an overall parasitism rate of 32.1%.
	s. Meterorus versicolor	A hymenopterous parasite of young larvae from Turkey (Oncuer, et al., 1977).
	t. Monodontomerus aereus	A primary torymid parasite of the pupae and also a secondary parasite of tachinid parasites of this host (Kusevska, 1977; Oncuer, et al., 1978; Grill & Caldumbide, 1987).
	u. Pales pavida	A tachinid larval parasite from Italy (Delirio & Luciano, 1985).
	v. Palesisa sp.	A tachinid larval and pupal parasite from Turkey (Oncuer, et al., 1978).
	w. Palesisa nudioculata	A tachinid larval parasite from Macedonia (Sisojevic, et al., 1976) with an overall parasitism rate of 45.4%.
	x. Parasarcophaga uliginosa	A sarcophagid parasite from England (Wyatt, et al., 1988).
	y. Pediobius bruchicida	A eulophid parasite of young larvae from Turkey (Oncuer, et al., 1977), but cited later as primarily a pupal parasite (Oncuer, et al., 1978).
	z. Pediobius pyrgo	A hymenopterous parasite of young larvae from Turkey (Oncuer, et al., 1977).
	aa. Pyemotes zwoelferi	A mite predator of young larvae from Turkey (Oncuer, et al., 1977).
	bb. Tachina praeceps	A tachinid parasite of mature larvae from Turkey (Oncuer, et al., 1977).

Pest Species	Parasites/Predators	Notes
	cc. Telenomus phalaenarum	A low rate of parasitism on this host in Europe (Anderson & Kaya, 1976).
	dd. Telenomus turkarkandas	A hymenopterous egg parasite from Italy (Tiberi, 1989). Parasitism rates range from 33.3 - 100%.
	ee. Tetrasticus sp.	A hymenopterous parasite of young larvae from Turkey (Oncuer, et al., 1977).
	ff. Townsendiellomyia nidicola	A tachinid larval parasite from England (Wyatt, et al., 1988).
	gg. Trichogramma endrolimi	A hymenopterous egg parasite from Italy (Tiberi, 1989). Parasitism and distribution are rather sporadic.
	hh. Trichogramma pretiosum	A low rate of egg parasitism on this host in North America (Anderson & Kaya, 1976).
	ii. Trichogramma sp.	A specifically unknown parasite with a low rate of egg parasitism in Europe (Anderson & Kaya, 1976).
	gg. Zenillia libatrix	A tachinid larval and pupal parasite from Turkey (Oncuer, et al., 1978).
Euproctis dewitzi	*a. Glyptapanteles africanus*	A braconid larval parasite from Africa (Walker, 1994).
Euproctis fraterna	*a. Henicospilus merdarius*	An ichneumonid larval parasite (?) from India, Malaysia, and Europe (Beeson & Chatterjee, 1935)
Euproctis kargalika	*a. Apanteles spp.*	A braconid larval parasite (Romanenko, 1981).
	b. Tachinidae sp.	A tachinid larval parasite (Romanenko, 1981).
	c. Trichomalopsis (=Eupteromalus) peregrinus	A chalcid parasite (Romanenko, 1981).
	d. Eriborus achalicus	An ichneumonid parasitoid from the USSR (Dbar & Saparmamedova, 1988).
Euproctis lunata	*a. Blepharella lateralis*	A parasite noted infecting 4.5% of the larvae in the field (Battu & Dhaliwal, 1977).
	b. Carcelia corvinoides	A dipterous larval parasite (Gurdip, 1981).
	c. Exorista larvarum	A dipterous larval parasite. With C. Corvinoides, it exerts a parasitism rate of 10-15% in July and August (Gurdip, 1981).
	d. Trichogramma exiguum	A hymenopterous egg parasite from India (Ram & Irulandi, 1989)

Pest Species	Parasites/Predators	Notes
Euproctis melania	*a. Apanteles sp.*	A hymenopterous larval parasite with a rate of 11.3 - 83.3% parasitism (Awadallah, et al., 1979).
	b. Brachymeria intermedia	A hymenopterous pupal parasite (Abai, 1976).
	c. Exorista sorbillans	A larval parasite (Abal, 1976).
	d. Pteromalus sp. nr. Dispar	A parasite of unknown import (Abadallah, et al., 1979).
Euproctis pseudoconspersa	*a. Telenomus suproctidis*	An important egg parasite from China (Wang, 1981).
	b. Parena rufotestacea	An important carabid predator from China (Long & Liu, 1986). Overwinters in the adult stage. Both larvae and adults prey on the host.
	c. Bessa parallela	A tachinid parasite from Japan (Shima, 1996).
	d. Exorista japonica	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	e. Hystricovoria bakeri	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	f. Isosturmia picta	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	g. Kuwanimyia conspersa	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	h. Pales pavida	A tachinid parasite from Japan (Schaefer & Shima, 1981).
Euproctis scintillans	*a. Apanteles flavipes*	A gregarious endoparasitoid from India (Senthamizhselvan, 1989).
	b. Henicospilus merdarius	An ichneumonid parasite(?) from India, Malaysia, and Europe (Beeson & chatterjee, 1935)
Euproctis similis	*a. Apanteles sp.*	A parasite (Wei, 1980).
	b. Apanteles inclusus	A parasite from China (Also known from India) (You, et al., 1983).
	c. Carcelia amphion	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	d. Carcelia bombylans	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	e. Compsilura concinnata	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	f. Exorista japonica	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	g. Hyleorus elatus	A tachinid parasite (Togashi, 1977; Schaefer & Shima, 1981).
	h. Hystricovoria bakeri	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	I. Pales pavida	A tachinid parasite from Japan (Schaefer & Shima, 1981)

Pest Species	Parasites/Predators	Notes
Euproctis subflava	*a. Aplomya confinis*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	b. Bassa parallela	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	c. Carcelia bombylans	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	d. Carcelia lucorum	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	e. Exorista japonica	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	f. Exorista rustica	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	g. Exorista mimula	A tachinid parasite from Japan (Shima, 1996).
	h. Hyleorus takanoi	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	I. Isosturmia picta	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	j. Nemorilla floralis	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
Euproctis subnotata	*a. Apanteles inclusus*	A larval parasite from India with a 9.2% parasitism rate (Lateef & Reddy, 1984).
Euproctis terminalis	*a. Glyptapanteles pseudacreae*	A hymenopterous parasite (Donaldson, 1981).
Euproctis xanthomelaena	*a. Glyptapanteles africanus*	A braconid larval parasite from Africa (Walker, 1994).
Euproctis xanthorrhoea	*a. Amyotea malabarica*	A predatory bug from India found on rice (Pati & Mathur, 1986).
Gastropacha quercifolia	*a. Telenomus tetratomus*	An egg parasite (Chen & Wu, 1981).
Hemerocampa pseudotsugata	*a. Trichogramma minutum*	Egg parasitization is high on this host in North America (Anderson & Kaya, 1976).

Pest Species	Parasites/Predators	Notes
Ivela auripes	*a. Carcelia bombylans*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	b. Carcelia gnava	A tachinid parasite from Japan (Togashi, 1988; Schaefer & Shima, 1981).
	c. Compsilura concinnata	A tachinid parasite from Japan (Togashi, 1988).
	d. Pales pavida	A tachinid parasite from Japan (Togashi, 1988; Schaefer & Shima, 1981).
	e. Cotesia melanoscelus	A braconid parasite from Japan (Togashi, 1988).
	f. Glyptapanteles liparidis	A braconid parasite from Japan (Togashi, 1988).
	g. Trichogramma chilonis	A hymenopterous parasite from Japan (Hirai, 1988).
	h. Exorista japonica	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	I. Zenillia libatrix	A tachinid parasite from Japan (Schaefer & Shima, 1981)
Ivela ochropoda	*a. Brachymeria lasus*	A chalcid pupal parasite with a parasitic rate of 30-68.5% on this host (Yan, et al., 1990).
	b. Chouioia cunea	A chalcid parasite (Yang, 1989).
Leucoma candida	*a. Bessa parallela*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	b. Trichogramma closterae	An overwintering egg parasite (Xia, et al., 1982; Yang & Li, 1984).
	c. Exorista sorbillans	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	d. Linnaemya media	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	e. Carcelia candidae	A tachinid parasite from Japan (Schafer & Shima, 1981).
Leucoma fasciata	*a. Amyotea malabarica*	A predatory bug from India found on rice (Pati & Mathur, 1986).
Leucoma salicis	*a. Agria housei*	A larval/pupal sarcophagid parasite (Wagner & Leonard, 1980).
	b. Apanteles solitarius = (melanoscelus)	A larval/pupal braconid parasite from Europe (Wagner & Leonard, 1980).
	c. Calosoma frigidum	A larval/pupal carabid predator (Wagner & Leonard, 1980).
	d. Carcelia laxifrons	A larval/pupal tachnid parasite (Wagner & Leonard, 1980).
	e. Cratichneumon viator	An ichneumon parasitoid (Selfa, et al., 1988).
	f. Compsilura concinnata	A larval/pupal tachinid parasite from Europe (Wagner & Leonard, 1980; Schaefer & Shima, 1981).

Pest Species	Parasites/Predators	Notes
	g. Diadegma praerogator	An ichneumonid parasite from Romania
	h. Eupteromalus hemipterus	An overwintering larval parasite (Wagner & Leonard, 1980).
	I. Exorista pretensis	A tachinid parasite from Bulgaria (Khubenov, 1983).
	j. Meterorus versicolor	A larval/pupal braconid parasite (Wagner & Leonard, 1980).
	k. Pimpla pedalis	A larval/pupal ichneumonid parasite (Wagner & Leonard, 1980).
	l. Pyemotes ventricosus	A predatory mite from India reported to prey on *Leucoma salicis* (Dakshinamurthy, 1987).
	m. Sarcophaga aldrichi	A larval/pupal sarcophagid parasite (Wagner & Leonard, 1980).
	n. Tachinomyia variata	A larval/pupal tachinid parasite (Wagner & Leonard, 1980).
	o. Telenomus californicus	Low egg parasitization on this host in North America (Anderson & Kaya, 1976).
	p. Telenomus mayri	Low egg parasitization on this host in Europe America (Anderson & Kaya, 1976).
	q. Telenomus nitidulus	An egg parasite on this host in Europe (Grijpma, et al., 1991). This parasite overwinters in the adult stage. Adults can survive for 12 months (Grijpma, 1986).
	r. Trichogramma evanescens	An egg parasite, which, with Trichogramma maidis, reached 68-80% parasitism in China (Ying & Chang, 1987).
	s. Trichogramma maidis	An introduced egg parasite from France, which, with *Tricogramma evanexcens*, reached 68-80% parasitism in China (Yin & Cheng, 1987).
	t. Trichogramma imnutum	Low egg parasitization on this host in North America (Anderson & Kaya, 1976).
	u. Trichogramma pintoi	High egg parasitization on this host in China, so good that mass rearing of this parasite has been carried out (Wang & Zhang, 1991).
	v. Bessa parallela	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
	w. Compsilura concinnata	A tachinid parasite from Japan (Shima, 1996 Schaefer & Shima, 1981).
	x. Linnaemya media	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	y. Pales pavida	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	z. Zenillia libatrix	A tachinid parasite from Japan (Schaefer & Shima, 1981).

Pest Species	Parasites/Predators	Notes
Leucoma wiltshirei	*a. Exorista longicercus*	A tachinid. See Kugler, 1979.
	b. Compsilura concinnata	A parasite listed by Adeli, 1980.
	c. Beauveria bassiana	An occasional larval parasite (Abai, 1981)..
Lymantria ampla	*a. Aleiodes sp.*	A braconid parasite from India (Ramaseshiah & Bali, 1987).
	b. Apanteles obliquae	A braconid parasite from India (Ramaseshiah & Bali, 1987).
	c. Apanteles sp. (glomeratus group)	A braconid parasite from India (Ramaseshiah & Bali, 1987).
	d. Euplectrus sp.	A eulophid parasite from India (Ramaseshiah & Bali, 1987).
	e. Brachymeria porthetrialis	A chalcidid parasite from India (Ramaseshiah & Bali, 1987).
	f. Blepharipa sp.	A tachinid parasite from India (Ramaseshiah & Bali, 1987).
	g. Carcelia sp.	A tachinid parasite from India (Ramaseshiah & Bali, 1987).
	h. Exorista sp.	A tachinid parasite from India (Ramaseshiah & Bali, 1987).
	I. Palexorista sp.	A tachnid parasite from India (Ramaseshiah & Bali, 1987)
Lymantria concolor	*a. Hyposoter lymantriae*	An ichneumonid parasite attacking the early larval stages in June-July, emergent in August. From India (Beeson & Chatterjee, 1935)
	b. Mesochorus facialis	An ichneumonid larval parasite (?) or hyperparasite on *Apanteles* spp. From India, China Europe (Beeson & Chatterjee, 1935)

Pest Species	Parasites/Predators	Notes
Lymantria dispar	a. *Actia jocularis*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	b. *Anastatus disparis*	An egg parasite with, generally, a low rate of parasitism rarely over 50% in North America, up to 25 or maybe 50% in Europe, and up to 25% in Asia for this host (Anderson & Kaya, 1976; Schaefer, 1988)).
	c. *Anastatus japonicus*	An egg parasite whose identity from A. disparis is not clear (Schaefer, et al., 1988).
	d. *Apanteles melanoscelus*	A braconid larval parasite capable of distinguishing between healthy larvae and larvae diseased by a NPV (Versoi & Yendol, 1978).
	e. *Blepharipa pratensis*	A tachinid larval parasite found most frequently during the preculminating phase of an infestation (Ticehurst, et al., 1978).
	f. *Blepharipa schineri*	A tachinid larval parasite (Schaefer & Shima, 1981); Candidate for introduction (Roger Furester, ARS, Newark, Delaware).
	g. *Blepharipa sericariae*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	h. *Blepharipa zebina*	A Tachinid parasite from Japan (Schaefer & Shima, 1981).
	I. *Brachymeria intermedia*	A chalcid pupal parasite found most frequently during the culmination phase of an infestation (Ticehurst, et al., 1978) Most important (90%) pupal parasite in New Jersey (Fuester, 1996).
	j. *Brachymeria lasus*	A chalcid pupal parasite used in the U.S. to help control gypsy moth through releases. This parasite searches for pupae within a 30 meter range (Simser & Coppel, 1980).
	k. *Calosoma sycophanta*	A carabid predator from Italy, capable of decimating entire populations of the host (Weseloh, 1985). The dominant predator in New Jersey (Fuester & Taylor, 1996) Release into areas of leading edge infestation where beetle is not abundant (Weseloh, et al., 1995).

Pest Species	Parasites/Predators	Notes
	l. Carcelia excisa	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	m. Carcelia separata	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	n. Calosoma frigidum	A carabid predator from North America which was recorded as the most numerous predator present on trees in New Hampshire (50%) during outbreak conditions (DuDevoir & Reeves, 1990).
	o. Ceranthia samarensis	A tachinid larval parasitoid from Europe which is the predominant parasitoid in low density populations of the host (Mills & Nealis, 1992). A candidate for introduction in the U.S. (Fuester, ARS, pers. comm.).
	p. Compsilura concinnata	A tachinid parasite from Japan (Shima, 1996) from *L.d.japonica; from* L. dispar (Schaefer, 1981).
	q Cotesia melanoscela	A braconid larval parasitoid from the NE U.S., which appears to parasitize the host at a rate from 3-23% (Gould, et al., 1992). A braconid larval parasite capable of distinguishing between healthy larvae and larvae diseased by a NPV (Versoi & Yendol, 1978).
	r. Dolichovespula maculata	A vespid predator of adult males in the Eastern U.S. (Schaefer, 1991).
	s. Exorista japonica	A tachinid parasite from Japan (Schaefer & Shima, 1981; Shima, 1996).
	t. Exorista larvarum	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	u. Glyptapanteles flavicoxis	A gregarious larval parasite (Hu, et al., 1986) from India, of *Lymantria obfuscata,* which readily attacks gypsy moth. *(Fuester, et al., 1987).*
	v. Grayon howardi	An egg parasite with a high rate (75-85%) of parasitism in Europe on this host (Anderson & Kaya, 1976).
	w. Grayon lymantriae	An egg parasite with a low rate of parasitism in Eupope on this host (Anderson & Kaya, 1976).
	x. Kranophorus extentus	An egg parasite with a low, up to 50% rate of parasitism in Europe on this host (Anderson & Kaya, 1976).
	y. Ooencyrtus kuwanai	An egg parasite with a parasitism rate of up to 33% in Asia and up to 33% in North America on this host (Anderson & Kaya, 1976; Schaefer, et al., 1988a).
	z. Pales pavida	A tachinid parasite from Japan (Schaefer & Shima, 1981).

Pest Species	Parasites/Predators	Notes
	aa. Parasetugena silvestria	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	bb. Parasetigena silvestris	A tachinid larval parasite found most frequently during the post-culmination phase of an outbreak (Ticehurst, et al., 1978).
		A tachinid larval parasite from NE U.S., with a parasitism rate of 16-64% (Gould, et al., 1992)
		A tachinid parasite from Japan (Shima, 1996).
	cc. Telenomus phalaenarum	A tachinid parasite on 2+% (Fuester & Taylor, 1996).
		An egg parasite with a low rate of parasitism for this host in Europe (Anderson & Kaya, 1976).
	dd. Telenomus sp.	An unknown egg parasite with a low rate of parasitism for this host in Europe (Anderson & Kaya, 1976).
	ee. Theronia atalantae fulvescens	A ichneumonid parasite on 0-5% of the population (Fuester & Taylor, 1996).
	ff. Glyptapanteles liparidis	A braconid parasite from Europe with a 0-15% parasitism rate (Fuester, et al., 1983).
	gg. Glyptapanteles porthetriae	A braconid parasite from France (Guester, et al., 1988).
	hh. Meteorus pulchricornis	A solitary, polyphagous braconid parasite on intermediate instars from Europe, with a 0-11% parasitism rate (Fuester, et al., 1983).
	ii. Phobocampe unicincta	A solitary, univoltine, monophagous ichneumonid larval parasite from Europe, with a 0-19% parasitism rate (Fuester, et al., 1983).
	jj. Parasetigena silvestris	An univoltine, oligophagous tachinid larval parasite from Europe with a 19-50% parasitism rate (Fuester, et al., 1983).
	kk. Hexamermis sp. nr. albicans	An univoltine, polyphagous(?) nematode from intermediate instars, with a parasitism rate of 0.2-11% (Fuester, et al., 1983).
	ll. Tyndarichus navae	An encyrtid hyperparasite of *Ooencyrtus kuvanae* (Schaefer, et al., 1988a).
Lymantria fumida	*a. Carcelia lucorum*	A tachinid parasite from Japan Schaefer & Shima, 1981).
	b. Exorista sorbillans	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981).
Lymantria lucescens	*a. Exorista japonica*	A tachinid parasite from Japan (Shima, 1996).

Pest Species	Parasites/Predators	Notes
Lymantria mathura	*a. Carcelia amphion*	A tachinid parasite of *L. m. aurora* in Japan (Schaefer &Shima, 1981).
	b. Carcelia excavata	A tachinid parasite of *L. m. aurora* in Japan (Togashi, 1977).
	c. Carcelia gnava	A tachinid parasite of *L. m. aurora* in Japan (Schaefer &Shima, 1981).
	d. Compsilura cocinnata	A tachinid parasite from Japan (Shima, 1996; Schaefer & Shima, 1981) from *L. m. aurora.*
	e. Turanogonia chinensis	A tachinid parasite of *L. m. aurora* in Japan (Schaefer &Shima, 1981).
	f. Winthemia sp. nr. neowinthemioides	A tachinid parasite of *L. m. aurora* in Japan (Schaefer &Shima, 1981).
	c. Winthemia sumatrana	A tachinid parasite from Japan (Shima, 1996) from *L. m. aurora.*
Lymantria monacha	*a. Apanteles inclusus*	A parasite from China (also known from India) (You, et al., 1983).
	b. Parasetigena silvestris	A tachinid larval parasite from the Netherlands (Steijlen, et al., 1987). This species occurs throughout Eurasia (Fuester, ARS, pers. comm.).
Lymantria obfuscata	*a. Anastatus sp.*	An eupelmid egg parasite in India. Capable of overwintering in host eggs. Parasitism rate of 16 to 21% (Singh & Lakshmi, 1987).
	b. Anastatus kashmirensis	A eupelmid egg parasite in India with a parasitsim rate of 3.5-9.9% (Amin, et al., 1986). Masoodi, et al., (1986), cited a similar rate (4.49-11.92%).
	c. Glyptapanteles flavicoxis	A braconid parasite from India (Marsh, 1979; Fuester, et al., 1987)
	d. Compsilura sp.	A tachinid larval parasite in India with a parasitism rate of 2.1-28.7% with the next species below (Amin, et al., 1986) Masoodi, et al.,(1986), cites a rate of 0.99%.
	e. Exorista rossica	A tachinid larval parasite in India with a parasitism rate combined with the parasite above (Amin, et al., 1986). Masoodi, et al., (1986), cites a rate of 8.42%.
	f. Brachymeria lasus	A hymenopterous pupal parasite in India with a parasitism rate of 1.3-20% in conjunction with 5 other parasites (Amin, et al., 1986) Masoodi, et al., (1986), cites an individual rate of up to 2.01%.
	g. Glyptapanteles flavicoxis	A gregarious larval parasite (Hu, et al., 1986) from India *(Fuester, et al., 1987).*
	h. Tetrastichus sp.	A dominant eulophid pupal parasite from India with a parasitism rate of 33.41% (Masoodi, et al., 1986).
	I. Pimpla sp.	An ichneumonid pupal parasite from India with a parasitism rate of 6.84% (Masoodi, et al., 1986)

Pest Species	Parasites/Predators	Notes
	j. Theronia atlantae	**An ichneumonid pupal parasite from India with a parasitism rate of 0.03% (Masoodi, et al., 1986).**
	k. Brachymeria intermedia	**A chalcidid pupal parasite from India with a parasitism rate of up to 2.98% (Masoodi, et al., 1986).**
Ocnerogyia amanda	*a. Brachymeria intermedia*	**A chalcidid pupal parasite from Iran (Abai & Faseli, 1986).**
Orgyia antiqua	*a. Hyposoter carbonarius*	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	b. Hyposoter vulgaris	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	c. Apanteles formosus	**A braconid parasite (Wellenstein & Fabritius, 1973).**
	d. Cotesia solitarius	**A major braconid parasite in Poland (Burzynski, 1978).**
	e. Astomaspis nanus	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	f. Campoplex unicinctus *g. Carcelia amphion*	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).** **A tachinid parasite (Wellenstein & Fabritius, 1973).**
	h. Carcelia puberula *I. Casinaria ischnogaster*	**A tachinid parasite (Wellenstein & Fabritius, 1973).** **An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	j. Casinaria nigripes	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	k. Casinaria senicula	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	l. Coccygomimus arcticus	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	m. Coccygomimus instigator	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	n. Coccygomimus turionellae	**An ichneumonid parasite (Wellenstein & Fabritius, 1973).**
	o. Comedo longicornis	**A chalcid parasite (Wellenstein & Fabritius, 1973).**
	p. Compsilura concinnata	**A tachinid parasite (Wellenstein & Fabritius, 1973).**

Pest Species	Parasites/Predators	Notes
	q. Ephialtes compunctor	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	r. Ephialtes rufatus	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	s. Exorista fasciata	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	t. Exorista larvarum	A tachinid parasite (Wellenstein & Fabritius, 1973).
	u. Euplectrus bicolor	A chalcid parasite (Wellenstein & Fabritius, 1973).
	v. Gregopimpla inquisitor	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	w. Iseropus stercorator	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	x. Macrocentrus cingulum	A braconid parasite (Wellenstein & Fabritius, 1973).
	y. Mesochorus pallidus	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	z. Nilea hortulana	A tachinid parasite (Wellenstein & Fabritius, 1973).
	aa. Ophion mocsaryi	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	bb. Pales pavida	A tachinid parasite (Wellenstein & Fabritius, 1973).
	cc. Phobocampe obscurella	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	dd. Phobocampe pulchella	A major ichneumonid parasite in Poland (Wellenstein & Fabritius, 1973).
	ee. Psycophagus omnivorus	A chalcid parasite (Wellenstein & Fabritius, 1973).
	ff. Rogas geniculator	A braconid parasite (Wellenstein & Fabritius, 1973).
	gg. Sagaritis raptor	An ichneumonid parasite (Wellenstein & Fabritius, 1973).
	hh. Telenomus dalmanni	Up to 70% egg parasitization on this host in Europe (Anderson & Kaya, 1979). Parasitizes overwintering eggs (Niemczyx, et al., 1978). Also a heavy parasite of this host in Chile (62.2 to 87.1%) (Carrillo & Mundaca, 1977).
	ii. Telenomus monticola	Reared from this host in China (Wu, et al., 1980).
	jj. Trichogramma caceciae	A very effective egg parasite, especially when combined with the insecticidal sprays DNOC (Krezotol and Karbolina DNC), fenitrothion or trichlorphon (Niemczyk, et al., 1982). These insecticides do not affect the parasite. Parasitizes everwintering eggs (Niemczyk, et al., 1978).
	kk. Trichogramma dendrolimi	A common egg parasite of this host in Europe (Niemczyk, et al., 1978).

Pest Species	Parasites/Predators	Notes
Orgyia leucostigma	a. *Cotesia melanoscelus*	A braconid larval parasite, whose venom facilitates the in vivotal persistence of a polydnavirus in the larvae (Stoltz, et al., 1988). This venom also permits the development of *Hyposoter exiquae, H. Fugitivus, and H. rivais* in the host (Guzo & Stoltz, 1985).
Orgyia mixta	a. *Glyptapanteles africanus*	A braconid larval parasite from Africa (Walker, 1994).
Orgyia postica	a. *Carcelia sp.*	A primary parasite (Howlader, 1979).
	b. *Telenomus sp.*	A primary egg parasite in Sumatra (Pardede, 1986).
	c. *Henicospilus striatus*	An ichneumonid larval parasite (?) from India, Bhutan, Malaysia, Indonesia (Beeson & Chatterjee, 1935).
Orgyia pseudotsugata	a. *Bracon xanthonotus*	A parasite (Luck & Dahlsten, 1980).
	b. *Carcelia valensis*	A pupal parasite, one of several tachinids that heavily parasitize the host (Dahlsten, et al., 1977).
	c. *Gambrus canadensis*	A parasite (Luck & Dahlsten, 1980).
	d. *Hyposter masoni*	A common parasite that probably requires another parasite in the host to complete its development (Torgersen, 1985; Guzo & Stoltz, 1985).
	e. *Metaphidippus aeneolus*	A predaceous spider with a predation rate of 86.7% under laboratory conditions (Mason & Paul, 1988).
	f. *Telenomus californicus*	A sclionid egg parasite with a 0-55.4% parasitism rate. Oviposits primarily in late March to mid-July, more rarely in the Autumn. Overwinters primarily as the adult female. Adults emerge in late summer (Torgersen & Ryan, 1981).
Orgyia similis	a. *Apanteles sp.*	A parasite (Wei, 1980).
Orgyia thyellina	a. *Carcelia amphion*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	b. *Carcelia bombylans*	A tachinid parasite from Japan (Schaefer & Shima, 1981).
	c. *Exorista japonica*	A tachinid parasite from Japan (Shima, 1996).
	d. *Trichogramma chilonis*	A hymenopterous egg parasite from Japan (Hirai, 1988).
Perina nuda	a. *Brachymeria croceogastralis*	A chalcid pupal parasite from India (David & Paul, 1975).
	b. *Psalis pennatula*	A predatory bug from India found on rice (Pati & Mathur, 1986).

Conservation of Predators and Parasites

Predation. Natural predation, aside from micro-organisms, consists of birds, small animals and various invertebrates. While such predation is unlikely to influence outbreak populations of a lymantriid, there is accumulating evidence that birds, ants, small mammals and other generalist predators are very important in suppressing lymantriid populations when the latter are already scarce (ie., gypsy moth, Elkinton, et al., 1988).

a. Bird Predation. Should it develop that a resident bird population will effectively reduce the numbers of a targeted pest, then the bird population in question should be disturbed as little as possible. If it is felt desirable, the birds can be encouraged to increase in numbers through:

- Provision of food during winter months
- Protection of nesting sites
- Discouragement of various bird predators
- Or possibly, control of diseases.

The results of work in Japan has shown tree sparrows (*Passer montanus*) to reduce the population of marked adults of *Leucoma candida* by 76.7 percent in one year and 98.7 percent in another year (Ueda, et al., 1981).

NOTE: The effect of other predators, such as *Labidura riparia*, *Thereuonema hilgendorfi*, and the starling *Sturnus cineraceus* were negligible.

In the United States, the black-billed cuckoo, *Coccyzeus erythrophthalmus*, is a good larval and pupal predator of the satin moth (*Leucoma salicis*). The hermit thrush, *Hylocichla guttata*, feeds on the adult.

In the American West, the red breasted nuthatch, *Sitta canadensis*; the dark eyed junco, *Junco hyemalis*; and the Nashville warbler, *Vermivora ruficapilla*, together account for about 52 percent of eggs lost to predation by *Orgyia pseudotsugata* (Togersen & Mason, 1987). In an earlier paper (1984), Togersen, et al., also listed the Mountain chickadee (*Parus gambeli*) as an egg predator.

In Connecticut, the black-capped chickadee, *Parus atricapillus*; the white-breasted nuthatch, *Sitta carolinensis*; the downy woodpecker, *Picoides pubescens*; and the blue jay, *Cyanocitta cristata*; destroyed about 40 percent of egg masses of *Lymantria dispar* over the winter. In this instance, the findings suggest that birds may have an important contributory role as egg mass predators whose impact would be greatest when prey populations are at low densities and continuous snow cover predominates in winter months (Cooper & Smith, 1995).

b. Small Mammal Predation. Small mammals frequently prey on late instars and pupae and can remove large proportions of these individuals from a population. Pupae at or near the ground tend to suffer greater losses.

Some mammals which feed on lymantriids include deer mice and shrews (Elkinton, et al., 1988). Specific species include the white-footed mouse, *Peromyscus leucopus*, and the shrews *Blarina brevicauda* and *Sorex cinereus*. Voles, such as the southern red-backed vole, *Clethrionmys gapperi,* the woodland jumping mouse, *Napaeozapus insignis,* and the opossum, *Didelphis marsupialis,* are also known to feed on lymantriid pupae or late-instar larvae (Cook, et al., 1995).

Small mammals which are known or observed to feed on lymantriid life stages can be protected by not destroying their habitat or reducing their numbers through hunting.

c. Insect Predation. There is apparently an inverse relationship between vertebrate and invertebrate predation levels. Pupal predation by vertebrates increases as small mammal density increases, but invertebrate predation decreases (Cook, et al., 1995).

Ants, in particular forest ants, attack early instar gypsy moth populations. *Formica neogagates, Formica subsericea, and Camponotus pennsylvanicus* are useful predators of the gypsy moth. Ant numbers may be increased by spraying hosts with sucrose, by encouraging benign (to hosts), host-dwelling honey-dew producing aphids, by providing food for ants during lymantriid off-season periods, or even by transporting ant nests into an area on a small scale. (Weseloh, 1994)

Spiders are another group of generalist predators that often consume the most abundant and most easily captured prey in their habitat. Lymantriid larvae have primary (hairs) and secondary (twitching, curling up) defenses, thus not all spiders will attack them at any given time. An incompletely investigated defense consists of chemical defenses from extrusible glands, "osmeteria", from the middle of abdominal segments 6 and 7 which may serve to repel predators (Deml & Dettner, 1995; Aldrich, et al., 1997). Lycosid spiders such as *Pardosa saxatilis* and *Paradosa milvina* will attack under no-choice conditions (Bardwell & Averill, 1996). Encouragement of spider populations at present consist of not disturbing them or observing which species may feed on the larvae and bringing in more of these spiders from elsewhere to feed on the target species.

Beetle predators appear to be another important group of invertebrates. The carabid, *Calasoma sycophanta*, is the dominant invertebrate mortality agent of gypsy moth (Fuester & Taylor, 1996). It is commercially available, but seems to work best through releases in leading edge areas where it is not already abundant (Weseloh, et al., 1995).

Other invertebrates of less importance include stink bugs (Pentatomidae) assassin bugs (Reduviidae), flower flies (Syrphidae), lacewings (Chrysopidae), hornets (Vespidae), and harvestmen (Phalangiidae). These may simply be avoided to conserve their numbers (Fuester & Taylor, 1996). Some are available commercially, but the efficacy of augmentative releases has not been demonstrated against the Lymantriidae.

Trunk Injection (Buitendag and Bronkhorst, 1980). For woody hosts, trunk injection of selected insecticides will effectively curtail the pest population attacking an injected host while protecting the predator/parasite population, except those individuals which may feed on or parasitize poisoned pests.

This technique is effectively limited to backyard situations or small areas, owning to its labor intensive nature and expense. Herbaceous hosts cannot be treated in this manner.

Materials

Dicrotophos or Monocrotophos 40% water soluble concentrate (WARNING: An Exemption May be needed)

20 ml disposable plastic syringes

Drill with 3.8 mm by 30 mm bit (minimum length)

Procedure

Drill 3.8 mm by 25 mm deep holes in the host, following the chart on the next page.

Prepare a locking hole in the syringes. This is a small hole drilled through and near the top of the cylinder when the plunger is 2/3 of the way out. The hole goes through both cylinder and plunger and is large enough to permit a nail to pass completely through the syringe.

Fill the syringe up to 1/3 full (never more) with the undiluted insecticide; then fill it up completely with air.

The syringe is now ready for use. It is inserted with a turning action into the hole prepared for it. The air in it is then compressed with the plunger, which is then held in position by passing the nail through the locking hole.

Absorption takes only a few minutes. This process is quicker when the hole is drilled through the longitudinal ridges of the trunk.

NOTE: It will take approximately 3 minutes per person to fill four syringes and attach them to the tree, and only a few seconds to remove them after absorption.

Treatment will be repeated every 4 - 6 weeks or following the advice of an advisory panel.

When Trunk Diameter 25 cm Above Ground is:	**Then Number of Syringes Needed is:**	**When Trunk Diameter 25 cm Above Ground is:**	**Then Amount of Insecticide in ml/tree is:**
<50 mm	1	25 mm	0.5
50 mm to 75 mm	2	50 mm	1.25
75 mm to175 mm	4	100 mm	3.75
		125 mm	5.0
		150 mm	7.5
>175 mm	6	200 mm	11.25
		250 mm	15.0

Newer treatments since 1980 include Mauget Micro-Injection among others. The following applies to Mauget micro-injection procedures:

Materials

- Imidacloprid (IMICIDE @ 10%, Dicrotophos (INJECT-A-CIDE B), @ 82% or Abamectin (INJECT-A-CIDE AV @ 1.9%)
- Personal protective equipment
- A portable drill
- A rubber mallet

- Injector units, 2 3/4" long plastic tube with 1/4" to 3/8" width diameter and fluted end
- Double-sealed capsules with pre-measured amounts of the insecticide

Procedure

Read "Directions For Use and Application of Mauget Injector Units," for specific details.

1/4" holes are drilled into a tree at 6" intervals with the mallet.

The injector units are hammered into the tree with the mallet, flush to the base of the shield.

The capsules are fitted, upended, onto the end of each injector unit to drain out.

Remove and dispose of the capsules promptly after treatment.

Note: See the instructions given with the capsules for full details and follow all safety directions, including storage and disposal.

For program needs, contact:

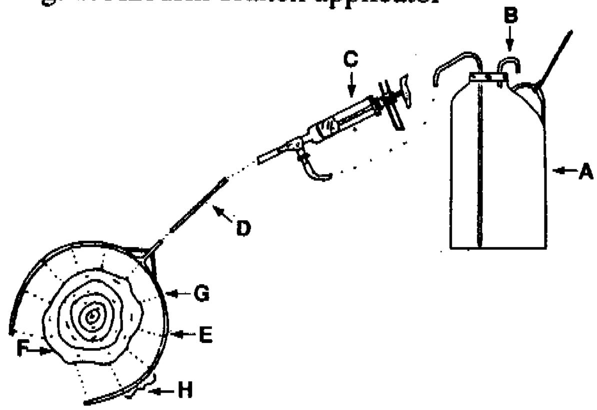
J.J. Mauget Company
2810 North Figeroa Street
Los Angeles, CA 90065

Band Treatment (Buitendag & Bronkhorst, 1986). This treatment, consisting of the free application of insecticide to the tree trunk with a trunk applicator or paint brush, is obviously less selective and somewhat more likely to endanger a parasite/predator population. However, the area of application is still out of the way of most parasite/predator and prey activity.

Materials

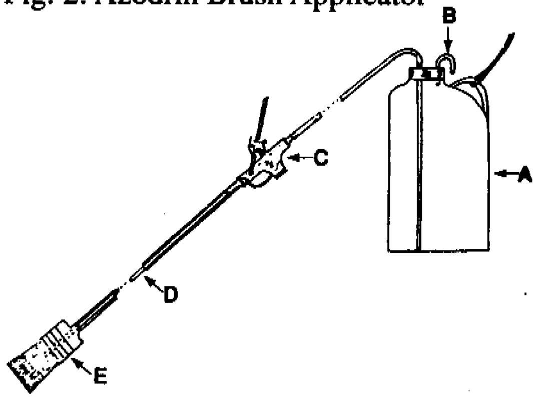
- Dicrotophos (Azodrin 400 g/l) or Imidacloprid (Merit, at label rates)
- Azodrin fork applicator or Azodrin brush applicator
  (figured) (figured)

Fig. 1: Azodrin branch applicator



Azodrin trunk applicator for bearing trees.
A = Azodrin plastic container; B = Air inlet; C = 20 ml automatic syringe; D = 5 mm Diameter supply pipe; E = Spray fork; F = Tree trunk; G = 0.75 mm Orifice and H = 50 mm for small fork and 20 mm for large fork.

Fig. 2: Azodrin Brush Applicator



Azodrin trunk applicator for small trees.
A = Azodrin plastic container; B = Air inlet; C = stop valve; D = 5 mm Diameter supply pipe and E = Brush

Procedure

Spray or brush the required amount of undiluted insecticide as given in the chart below. Cover the trunk with a wet band at the width given in the third column. Monthly treatments will be required.

Trunk Circumference in mm (inches)	ml of Azodrin Needed	Width of Azodrin Band in mm (inches)
30 (≈1 1/5")	0.1	9 (≈1/3")
40 (≈1 ½")	0.15	13 (≈½")
50 (≈2")	0.3	16 (≈2/3")
100 (≈4")	0.8	32 (≈1 1/4")
150 (≈6")	1.0	48 (≈2")
200 (≈8")	2.8	64 (≈2 ½")
250 (≈10")	4.8	80 (≈3")
300 (≈12")	6.5	96 (≈3 3/4")
350 (≈14")	10.0	111 (≈4 ½")
400 (≈16")	15.5	127 (≈5")
450 (≈18")	24.0	143 (≈5 ½")
500 (≈20")	35.0	159 (≈6 1/4")
550 (≈22")	50.0	175 (≈7")
600 (≈24")	70.0	191 (≈7 ½")

Insecticides. The following table charts those insecticides that have proven to be effective for tussock moths. Specifics are given, where possible, under each insecticide. Some compounds, such as certain pyrethoids, should be preferred if they exhibit little or no toxicity towards any predators and parasites that may be present or introduced in an area.

It should be remembered that nongenetic resistance may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action, including the effectiveness of chemical pesticides by stimulating insects that detoxify pesticides or by inhibiting insect enzymes that activate them (Appel & Schultz, 1994).

TABLE OF INSECTICIDES Used for Lymantriid Moths

Pest Species	Insecticide	Specifics
Euproctis chrysorrhoea	**Deltamethrin**	**Use Decis ULV before budbreak followed in spring by a Bt formulation (Lesko, 19840**
Euproctis lunata	**Chlorpyrifos**	**Use as a full cover spray at a concentration of 0.05% (Gerwal, et al., 1982)**
Euproctis similis	**Oleocuprit**	**A preparation consisting of petroleum oil and organic copper salt, and an emulsifer. Use at a rate of 2.5-5% when buds are swelling (Gar, et al., 1977)**
Euproctis subnotata	**Permethrin**	**Use at 50 g/ha fogging to greatly reduce numbers (Sujan, et al., 1985)**
Leucoma salicis	**Deltamethrin**	**Use 12.5 mg/liter of Decis as a spray (Lapietra, 1978)**
Lymantria monacha	**Deltamethrin**	**Use 2.5% Decis EC aerially at 0.15 liters/ha (Sokolowski & Wisniewski, 1987; Bychawska, 1986)**
	Permethrin	**Use as per instructions (Ambush formulation) (Bychawska, 1986)**
Orgyia antiqua	**DNOC**	**Use just before bud burst at recommended dosages, when combined with parasite releases (Niemczyk, 1982)**
	Fenitrothion	**Use 0.25% Agria 1050 at a rate of 100 liters/decare just after flowering, when parasites are employed (Niemczyk, et al., 1982)**
	Trichlorphon	**Use at recommended dosages, when combined with parasite releases (Niemczyk, et al., 1982)**

Pest Species	Insecticide	Specifics
Orgyia gonostigma	Deltamethrin	Use 0.02% Decis at a rate of 100 liters/decare (Trenchev & Pavolv, 1982)
	Fenitrothion	Use 0.25% Agria 1050 at a rate of 100 liters/decare (Trenchev & Pavolv, 1982)
	Parathion-methyl	Use 0.15% Wofatox at a rate of 100 liters/decare (Trenchev & Pavlov, 1982)
	Phosmet	Use 0.15% Imidan at a rate of 100 liters/decare (Trenchev & Pavolv, 1982)
	Tetrachlorvinphos	Use 0.5% Gardona at a rate of 100 liters/decare (Trenchev & Pavolv, 1982)
Orgyia leucostigma	Permethrin	Use at 70 ml/ha (Embree, et al., 1978)
Orgyia prisca	Dimethoate	Use as a full-cover spray at the rate of 1200 liters of Bi 58 per hectare (Akhmedov, 1982) May also be used at a sublethal dose as a combined treatment with *B. t.* subsp. *dendrolimus* to obtain the same mortality (Akhmedov, 1982) NOTE: Broad spectrum insecticide
Orgyia pseudotsugata	Acephate	Use as a full cover spray as per instructions. This is fast acting with a short residual effect. Minimal effect on non-target organisms (Anon., 1980).
Orgyia thyellina	"Natural" Pyrethrum	Proposed for use on localized infestations of late instars as a ground spray (OEG EIS, 1996)

Spray Volume Measurement as an Interface for Field Efficacy Data. If spray volume is assessed on the ground beneath trees or at tree drip lines, the dosage to which insects are actually exposed can be realistically estimated.

In this procedure, four clusters of 10 trees each are sampled. Each cluster encompasses an area of 60 by 100 m^2 and the clusters are at least 100 m from each other. Sample trees should be 9 to 12 m high, in open growth, and unsheltered by higher trees. Under the trees, spray deposits are assessed with aluminum plates under and adjacent to each tree. Spray volume (V_o) estimates from under the trees can converted to % loss of volume sprayed (V_s) by:

$$L_o = \frac{V_s - V_d}{V_s} \times 100$$

The percent loss predicted (L_p) by each conversion factor © is calculated by:

$$L_p = (1 - \frac{1}{C}) \times 100\%$$

The dosage (Y) for use in the model may now be calculated from the spray concentration released from the helicopter:

$$Y = \frac{18.0\ g}{1.0\ l} \times V_d$$

This dosage may be used with a laboratory-based efficacy model to calculate expected mortality within 5% of that actually occurring. This procedure permits more precise selection of dosages, timing of spray applications and the identification of situations needing correction (Williams & Robertson, 1983).

Deposition Distribution of Aerial Releases. Computer models to predict the deposition distribution of aerially released materials have been developed in response to the increasing need to control the drift. There are two current models. One is the AGDISP (for Agricultural DISPersal) and the other is the FSCBG (for Forest Service, Cramer, Barry and Brim, its developers). A description of the AGDISP model can be found in Bilanin, et al., 1989. The FSCBG model is described in Teske, et al., 1993.

Synchrony of Lymantriid Outbreaks. It has been determined that the Moran effect, a hypothesis that local population oscillations, which result from similar density-dependent mechanisms operating at time lags, is synchronized over wide areas by exposure to common weather patterns. If and when such a weather pattern appears to develop, then preventative measures aimed at population suppression should be put into place to prevent a population explosion of the target lymantriid (Williams & Liebhold, 1995).

Probability Model of Insecticidal Efficacy. A computer model based on probability theory should be set to simulate insecticide efficacy against the target pest. The following variables should be included:

a. Insecticide dosage at the foliage-insect level,
b. Genetically determined response characteristics of the target population to the insecticide,
c. Instar distribution of the population on the day of the spray,
d. Type of exposure,
e. Moisture condition of foliage at time of spray,
f. Amount of rainfall after spray,
g. Presence or absence of larvae at the time of spray.

(See Force, et al., 1982)

Efficacy of Viral Sprays. While much work remains to be done on efficacy and application of viral agents, the transmission dynamics of NPV suggest that application at the late instar stages of a target population will be the most effective. This is because transmission to healthy late instars, which are more likely to become infected, is unaffected by the patchiness of the distribution of the lymantriid population, whereas patchiness does affect transmission to early instars (Dwyer, 1991).

Some experimental work is also being undertaken at the USDA Insect Biology and Population Management Research Laboratory in Tifton, Georgia, involving the use of honeybees. Talc, laden with a specific virus harmless to the bees, is placed at the entrance to their hives. The bees are dusted with the talc on leaving the hive and therefore spread it to the flowers and other places they may visit. Provided that a given virus is harmless to bees and toxic to the target pest and also that at least some hosts of the target pest are also frequented by bees, then this is a possible low-cost technique during host flowering. How efficacious such a treatment would be is unknown at present, but undoubtedly it would have to be employed in conjunction with other measures.

Control through Pheromone Disruption & Mass Trapping. Properly applied, this treatment can be used as a stand-alone option, or used with other methods for eradication (Anon., 1990; Marshall & Clark, 1984). Two types of disruption are mass trapping and male confusion through pheromone sprays.

Disruption may cause delays in mating. If there is a delay in mating of 3-5 days in *Lymantria dispar*, for example, the reproductive potential of females is reduced by 40 percent to 90 percent. This could be a useful feature in dealing with many, if not all species, of lymantriids (Proshold, 1996).

One variation with mass trapping is the addition of pesticides or biological insecticides to the pheromone in the trap. It appears that such additions do not detract from the drawing power of the pheromone (Sower & Shorb, 1985; Lameris, et al., 1985).

A further distinction should be made between mass trapping with the intent of killing the moths and mass trapping with the intent of letting them escape to infect others with a disease or other pathogen placed in an open trap (Lameris, et al., 1985).

For more specific information, see Table D in 1. Biological Insecticides.

ADDENDUM 6

Special Considerations for Home Gardens

Factors in Regulatory Decisions:

Home gardens and similar situations may present a lower risk of lymantriid spread because their produce may not be commercially distributed and they may (or may not) be well tended to and treated for pests. Because home gardens are diverse and occur in diverse situations, survey techniques, regulatory actions, and control, suppressive or eradicative procedures will be decided on a case by case basis. Procedures are usually or should be mutually approved by cooperating State and local regulatory officials. Factors in regulatory decisions include:

- Proximity of site to areas of commercial production.
- Size of garden.
- Movement of hosts and pest.
- Changes in size or location of garden on a property over the years.
- Proximity of site to dwellings.
- Suitability of the lymantrid to regulatory measures.

Some of these factors may also apply to the choice of survey, control, suppressive, or eradicative techniques at commercial sites.

Regulatory Options:

These include:

- Control, suppression, or eradication measures.
- Prohibition of host crops at the infected site.
- Host crops of special value, such as those borne by trees in the genera *Prunus* or *Malus* may need significantly stronger controls to avoid their being taken out of the quarantine area.

Alternative options may be developed if deemed necessary. A quarantine or compliance agreement may or may not be required.

ADDENDUM 7

Life History

Systematic Position:

Class: Insecta
Order: Lepidoptera
Family: Lymantriidae (Tussock Moths)

The species listed below are those taken from the literature which are either pests, or seem to show some promise of being pests. The criteria involved included reputation, location, available life information, and recorded hosts. Of course, most, if not all lymantrids, will likely prove to be adaptable and may utilize new hosts in a new environment. For that reason, other still unrecognized species could also prove to be pests, especially if established in a new geographical area.

Common Name	Scientific Name	Geographical Distribution
White tussock moth, a	*Arctornia alba*	China (Wang, 1982); Korea, Japan (Chung-Ling, 1992)
---	*Arctornis gelasphora*	China (Chung-Ling, 1992)
White tussock moth, a	*Arctornia l-nigrum*	China (Wang, 1982); Korea, Japan, Russia, Europe (Chung-Ling, 1992)
NOTE: Bacallado, et al., 1981, states that *Dasychira* is restricted to the New World. Some local reassignments, including a new genus were given as indicated below.		
---	*Arctornis xanthochila*	China (Chung-Ling, 1992)
---	*Aroa substrigosa*	China, Vietnam, India (Chung-Ling, 1992)
---	*Calliteara cerigoides*	Indonesia (Messer, et al., 1992)

Common Name	Scientific Name	Geographical Distribution
Pale tussock moth	*Calliteara (=Dasychira) (=Elkneria) pudibunda* (Holloway, 1982)	Germany (Klimetzek, 1984); England (Greenwood & More, 1981); Spain (Bacallado, et al., 1981); USSR (Chistyakov, 1981); Poland (Karczewski, et al., 1978); Sweden (Nilsson, 1978); Central Asia, Japan (Carter, 1984) Europe to Sweden, Southern Finland, Britain, Ireland (Holden, 1998)
---	*Cifuna eurydice*	China, Japan (Chung-Ling, 1992)
---	*Cifuna jankowskii*	China, Japan (Chung-Ling, 1992)
---	*Cifuna locuples*	China, Tibet, Japan, Korea, Vietnam (Chung-Ling, 1992)
---	*Dasychira abietis*	Europe (Anderson & Kaya, 1976)
---	*Dasychira angulata*	China, Burma, Sikkim, India (Chung-Ling, 1992)
Sugi tussock moth	*Dasychira argentata*	Japan (Shibata, 1981)
---	*Dasychira aurifera*	China, Tibet, Japan (Chung-Ling, 1992)
Pine tussock moth	*Dasychira axutha*	China (Chen & Wu, 1981); Japan (Chung-Ling, 1992)
---	*Dasychira baibarana*	China (Xia, et al., 1982); Taiwan, Japan (Chung-Ling, 1992)
——	*Dasychira basalis*	East Africa (Holden, 1998)
Dark tussock moth	*Dasychira basiflava*	Eastern US (Baker, 1972)
---	*Dasychira chekiangensis*	China (Chung-Ling, 1992)
---	*Dasychira chinensis*	China (Chung-Ling, 1992)
---	*Dasychira conjuncta*	China, Mongolia, Japan (Chung-Ling, 1992)

Common Name	Scientific Name	Geographical Distribution
---	*Dasychira dalbergiae*	India (Chander & Dogra, 1983)
---	*Dicallomera (=Dasychira) fascelina*	Spain (Bacallado, 1981)
---	*Macaronesia (=Dasychira) fortunata*	Western Canary Islands (Bacallado, 1981)
---	*Dasychira glaucinoptera*	China (Xia, et al., 1982)
---	*Dasyrchira grotei*	China (Wu & Huang, 1986); India (Chander & Dogra, 1983); Taiwan (Chung-Ling, 1992)
Yellow hairy caterpillar	*Dasychira horsfieldi*	India (Gupta, et al., 1989); China, Sri Lanka, Sikkim, Indonesia (Chung-Ling, 1992)
---	*Dasychira inclusa*	Indonesia, Hong Kong (Holden, 1998)
---	*Dasychira locuples*	China (Zhu, et al., 1980); Japan (Kidokoro & Maeda, 1982); Tibet, Korea, Vietnam (Chung-Ling, 1992)
---	*Dasychira lunulata*	China, Korea, Japan (Chung-Ling, 1992)
---	*Dasychira manto*	Mississippi, Louisiana, Alabama (Holden, 1998)
---	*Dasychira mendosa*	India (Palaniswami & Pillai, 1981); Bangladesh (Das, 1990); Southern Asia (Hill, 1985); Australia (Ironside, 1980)
---	*Dasychira pennatula*	China, Tibet, Taiwan, Burma, India, Sri Lanka, Indonesia, Africa, Australia (Chung-Ling, 1992)
Pine tussock moth	*Dasychira plagiata*	NE US to Lake States, SE Canada (Baker, 1972); China, Tibet, Nepal (Chung-Ling, 1992)
---	*Dasychira securis*	India (Kundu, 1983)
---	*Euproctis aethiopiaca*	Africa (Walker, 1995)

Common Name	Scientific Name	Geographical Distribution
---	*Euproctis bipunctapex*	Singapore (Lee, et al., 1991); China (Wang, 1981); Sumatra (Schintlmeister, 1994); Tibet, India (Chung-Ling, 1992)
Browntail moth	*Euproctis chrysorrhoea*	Turkey (Oncuer, et al., 1982); England (Sterling, 1983); Spain (Munoz & Ruperez, 1980); Poland (Sliwa & Swiezynska, 1978); Germany (Vater, 1980); Belgium (Lebrun & Vlayen, 1979); Yugoslavia (Sidor, 1980); Hungary (Lesko, 1984); Netherlands (Doom, 1979); Czechoslovakia (Krejzova, 1978); Croatia (Novakovic et al., 1989); Switzerland (Keimer, 1989); France (Grill & Caldumbide); Italy (Scortichini, 986); Bulgaria (Atanasov, 1984); Massachusetts (Leonhardt, et al., 1991); Eastern North American seaboard (Holden, 1998); North Africa, Central Asia (Carter, 1984); Canary Island (Holden, 1998); New England, New Brunswick, Nova Scotia (Baker, 1972); Europe (Anderson & Kaya, 1976)
---	*Euproctis cryptosticta*	China (Chung-Ling, 1992)
---	*Euproctis dewitzi*	Africa (Walker, 1994)
---	*Euproctis digramma*	China, Burma, India, Indonesia (Chung-Ling, 1992)
Mistletoe browntail moth	*Euproctis edwardsi*	New South Wales (Thompson, 1984); Queensland, Victoria, South Australia (Holden, 1998)

Common Name	Scientific Name	Geographical Distribution
---	*Euproctis fasciata*	Kenya (Sevastopulo, 1981); Nigeria (Apeji, 1980)
Oriental tussock moth	*Euproctis subflava (=flava)*	China (Tsia & Ding, 1982); Japan (Kawamoto, et al., 1977); Korea (Ahn, et al., 1989)
---	*Euproctis flavinata*	China, India, Sri Lanka (Chung-Ling, 1992)
---	*Euproctis flavotriangulata*	China (Chung-Ling, 1992)
Plum hairy caterpillar	*Euproctis fraterna*	India (Manoharan, et al., 1982); China, Sri Lanka (Chung-Ling, 1992)
---	*Euproctis icilia*	India (Khan & Srivastava, 1990)
---	*Euproctis kargalika*	USSR, Kirgizia (Romanenko, 1981)
---	*Euproctis latifascia*	China (Chung-Ling, 1992)
Castor hairy caterpillar	*Euproctis lunata*	India (Srivastava, et al., 1983); Bangladesh (Islam, et al., 1988); China (Chao, 1984); Burma, Sri Lanka (Chung-Ling, 1992)
---	*Euproctis lutifacia*	India (Kumaresan, et al., 1987)
---	*Euproctis melania*	Iraq (Awadallah, et al., 1979); Iraq, Turkey (Abai, 1976)
---	*Euproctis mesostiba*	China (Chung-Ling, 1992)
---	*Euproctis montis*	China (Chung-Ling, 1992)
---	*Euproctis niphonis*	China, Japan, Korea (Chung-Ling, 1992)
---	*Euproctis phaeorrhoea*	Czechoslovakia (Kneifl, 1977)
---	*Euproctis producta*	Africa (Hill, 1975)
Tea lymantrid	*Euproctis pseudoconspersa*	China (Wang, 1981); Japan (Hill, 1985); Europe (Chung-Ling, 1992)

Common Name	Scientific Name	Geographical Distribution
Castor hairy caterpillar	*Euproctis scintillans*	India (Koshiya, et al., 1977); Sri Lanka (Shanathichandra, et al., 1990); China (Shi, et al., 1984); Burma, Malaysia, Singapore, Indonesia, Pakistan (Chung-Ling, 1992)
Gold-tail moth	*Euproctis similis*	China (Wang, 1982); Korea (Chung-Ling, 1992); UK (Port & Thompson, 1980); Turkey (Kiziroglu, 1982); USSR (Stus', 1980); Germany (Purrini, 1979); Japan (Togashi, 1977); England, Wales, Ireland, Scotland, Central & Southern Europe, Central Asia (Carter, 1984)
---	*Euproctis staudingeri*	China, Tibet, Japan (Chung-Ling, 1992)
---	*Euproctis straminea*	China (Chung-Ling, 1992)
Sorghum earhead hairy caterpillar	*Euproctis subnotata*	India (Hardas, et al., 1978); Malaysia (Sujan, et al., 1985)
---	*Euproctis taiwana*	Taiwan (Wang, C.L., 1982); China (Chung-Ling, 1992)
---	*Euproctis terminalis*	South Africa (Geertsema, et al., 1978)
---	*Euproctis varian*	China, Malaysia, India (Chung-Ling, 1992)
---	*Euproctis virguncula*	India (Sandhu & Deol, 1975)
Golden moth	*Euproctis vitellina*	India (Chander & Dogra, 1983)
---	*Euproctis xanthomelaena*	Africa (Walker, 1994)
---	*Euproctis xanthorrhoea*	India (Sethi & Garg, 1983)
---	*Gastropacha quercifolia*	China (Chen & Wu, 1981)
Steppe caterpillar, a	*Gynaephora aureata*	China (Chou & Ying, 1979)

Common Name	Scientific Name	Geographical Distribution
Steppe caterpillar, a	*Gynaephora minora*	China (Chou & Ying, 1979)
Steppe caterpillar, a	*Gynaephora qinghaiensis*	China, Tibet (Chou & Ying, 1979)
Steppe caterpillar, a	*Gynaephora ruoergensis*	China (Chou & Ying, 1979)
---	*Gynaephora selenitica*	Northern Europe (Holden, 1998)
Yellow-legged tussock moth	*Ivela auripes*	Japan (Togashi & Kodnai, 1990); China, Korea (Chung-Ling, 1992)
---	*Ivela ochropoda*	China (Yan, et al., 1990)
Reed tussock moth	*Laelia coenosa*	China (Li, 1987); Vietnam, Japan, Europe (Chung-Ling, 1992)
---	*Laelia fasciata*	India (Pati & Mathur, 1986)
White tussock moth, a	*Laelia monoscola*	China (Want, 1982)
White tussock moth, a	*Leucoma candida*	China (Wang, 1982); Japan (Ueda, et al., 1981); Korea (Kuwana, 1986); Mongolia, Europe (Change-Ling, 1992)
Satin moth	*Leucoma salicis*	New England, Maritimes, Washington, Oregon (Baker, 1972); British Columbia, Alberta, Ontario, Quebec (Holden, 1998); England, Ireland (Holden, 1998); Bulgaria (Zakharieva, 1983); Germany (Kechel, 1979); Hungary (Szalay-Marzso, et al., 1981); USSR (Christyakov, 1981); Italy (Allegro, 1989); Netherlands (Doom, 1979); Switzerland (Maksymov, 1980); Polant (Ziemnicka, 1976); Turkey (Cobanoglu, 1992); China (Tsai, et al., 1978)
---	*Leucoma sericea*	India (Bhat, 1989)

Common Name	Scientific Name	Geographical Distribution
---	*Leucoma wiltshirei*	Iran (Kugler, 1979)
---	*Lymantria ampla*	India (Pramamik & Basu, 1975)
Grey black hairy caterpillar	*Lymantria concolor*	India (Bhardwaji, 1987); China, Vietnam, Sikkim (Chung-Ling, 1992); Taiwan (Schaefer, pers. Comm.)
Gypsy moth	*Lymantria dispar*	Europe, North America, Asia (Anderson & Kaya, 1976); North Africa, China, Japan (Carter, 1984); Korea (Chung-Ling, 1992); NE States down to North Carolina, West to Michigan, (Baker, 1972)
---	*Lymantria dissoluta*	China, Taiwan
---	*Lymantria fumida*	Japan, China, Taiwan (Schaefer, pers. Comm.)
---	*Lymantria incerta*	China, India, Sri Lanka (Chung-Ling, 1992)
---	*Lymantria juglandis*	China (Chao, 1984a)
---	*Lymantria lapidicola*	Turkey, Cyprus, Syria, Lebanon, Israel, Jordan, Iraq (Talhouk, 1977)
---	*Lymantria lunata*	Philippines, Australia (Holden, 1998)
---	*Lymantria marginata*	India (Singh, 1989); China, Sikkim (Chung-Ling, 1992)
Rosy Russian Gypsy Moth	*Lymantria mathura*	China (Tsia & Ding, 1982); Korea *L. m. Aurora* (Holden, 1998); Japan (Togashi, 1977); Taiwan, India (Schaefer, pers. Comm.); Russian Far East (Zlotina, et al., 1998)
---	*Lymantria modesta*	South Africa, Mozambique, Rhodesia, Zambia, Malawi, Angola, to Kenya (Pinhey, 1975)

Common Name	Scientific Name	Geographical Distribution
Nun moth	*Lymantria monacha*	British (Isles Holden, 1998); Germany (Schneider, 1981); Czechoslovakia (Skuhravy & Zumr, 1981); Netherlands (Doom, 1979); Switzerland (Maksymov, 1978); Poland (Cwiklinski, 1989); Latvia (Vitola & Ozols, 1989); Central Asia, China, Japan (Carter, 1984)
---	*Lymantria monomonis*	China, Japan (Chung-Ling, 1992)
---	*Lymantria nebulosa*	China, Taiwan (Chung-Ling, 1992)
---	*Lymantria ninayi*	Papua New Guinea (Roberts, 1978)
Kashmir willow defoliator	*Lymantria obfuscata*	Nepal (Adhikari, 1978); India (Roonwal, 1977)
Casuarina tussock moth	*Lymantria xylina*	Taiwan (Chang, 1991); China (Cheng, et al., 1987); Japan, India (Chung-Ling, 1992)
Fig tree defoliator	*Ocnerogyia amanda*	Iran (Asbai & Faseli, 1986)
Rusty tussock moth	*Orgyia antiqua*	Southern Canada, Northern US (Baker, 1972); Bulgaria (Trenchev & Pavlov, 1982); Poland (Niemczyk, et al., 1982); USSR (Galetenko & Pastukh, 1980); China (Wei, 1980); Chile (Santis, et al., 1979); Czechoslovakia (Svestka & Vankova, 1978); Scotland (Pinder & Hayes, 1986); North Africa, Siberia (Carter, 19874); New Zealand (Holden, 1998) (Mistaken reference to *O. Thyellina-Schaefer, pers. Comm.)*

Common Name	Scientific Name	Geographical Distribution
---	*Orgyia basalis*	Zimbabwe (Odendaal, 1980); Nigeria (Osisanya, 1976)
Definite-marked tussock moth	*Orgyia (=Hemerocampa) definita*	Southern Ontario, Eastern States (Baker, 1972)
---	*Orgyia detrita*	North Carolina (Drooz, et al., 1986)
---	*Orgyia (=Heteronygmia) dissimilis*	Tanzania (Rwamputa & Schabel, 1986)
Heath vapourer	*Orgyia ericae*	China (Zhang, et al., 1991); USSR (Pupavkina, 1985)
---	*Orgyia gonostigma*	Bulgaria (Trenchev & Pavlov, 1982); Romania (Minoiu & Boaru, 1989); USSR (Sevryukova, 1979); China, Korea, Japan (Chung-Ling, 1992); Italy (Ivanova, 1984)
Whitemarked tussock moth	*Orgyia leucostigma*	Canada (Grant, 1981); Michigan (Wilson, 1991); Mississippi, Louisiana (Thompson & Solomon 1986); Alabama and other States (Holden, 1998); Eastern US and Canada (Baker, 1972)
---	*Orgyia mixta*	Africa (Walker, 1994)
Cocoa tussock moth	*Orgyia postica*	Taiwan (Wang, 1982a); Bangladesh (Howlader, 1979); India (Subba-Rao, et al., 1974a); Taiwan (Wu, 1977); China (Shi, et al., 1984); Indonesia (Pardede, 1986)
Turkestan vapourer	*Orgyia prisca*	Turkestan, USSR (Akhmedov, 1982)

Common Name	Scientific Name	Geographical Distribution
Douglas-fir tussock moth	*Orgyia pseudotsugata*	Minnesota (Rose, 1983); Oregon (Colbert & Wong, 1979); Idaho (Kessler, et al., 1981); British Columbia (Lee, et al., 1983); Western North America (Linnane & Stelzer, 1982); New Mexico (Soer, et al., 1979); North America (Anderson & Kaya, 1972)
White spotted tussock moth	*Orgyia thyellina*	Japan (Sato, 1979); Korea, Taiwan, China, Russia (Far East) (OEG EIA, 1996); Introduced and eradicated from New Zealand (Schaefer, pers. Comm.)
Western tussock moth	*Orgyia vetusta*	California, Mexico (Savela, 1998)
---	*Pantana phyllostachysae*	China (Chao, 1977)
Chinese bamboo tussock moth	*Pantana sinica*	China (Wei, 1987)
---	*Parocneria furva*	China (Chung-Ling, 1992)
---	*Perina nuda*	India (Ghorpade & Patil, 1991); SE Asia, China (Hill, 1985)
---	*Pida strigipennis*	China, Burma, Malaysia, India, Sri Lanka (Chung-Ling, 1992)
---	*Porthesia atereta*	China, Tibet, Malay Peninsula (Chung-Ling, 1992)
---	*Porthesia kurosawai*	China, Japan, Taiwan, Korea
---	*Porthesia piperita*	China, Japan, Korea
---	*Psalis pennatula*	India (Sethi & Garg, 1983); China, Tibet, Taiwan, Burma, Sri Lanka, Indonesia, Africa, Australia (Chung-Ling, 1992)
White tussock moth, a	*Redoa anser*	China (Wang, 1982)

Common Name	Scientific Name	Geographical Distribution
White tussock moth, a	*Redoa anserella*	China (Wang, 1982)
White tussock moth, a	*Redoa cygnopsis*	China (Chung-Ling, 1992)
White tussock moth, a	*Redoa phaecraspeda*	China (Wang, 1982)
---	*Rolepa unimoda*	Brazil (Peres-Filho & Berti-Filho, 1985)
---	*Stilpnotia melanoscela*	China (Chung-Ling, 1992)
Black hairy caterpillar	*Varmina indica*	India (Chander & Dogra, 1983)

Biology:

The following biology is based on those species for which information is available and which may differ in some particulars from a generalized biology.

a. *Calliteara cerigoides*

Eggs hatch in 10.4 days on average. Several egg parasites reduce the population by 78 percent. Larval instars last 7-9 days. Females deposit egg masses of 283 eggs on tree stems.

Larvae have urticating hairs harmful to humans (Nesser, et al., 1992).

b. *Calliteara (=Elkneria =Dasychira) pudibunda*

The eggs are laid in groups of up to 300 on the branches, bark, or leaves of the food plant. They hatch in about 3 weeks (Carter, 1984). Larvae are found in the field from May to October (in Spain). The larvae pupate in a silken cocoon on the bark or leaves, usually at the base of the foodplant, often under moss or between fallen leaves (Carter, 1984). Individuals of the second generation overwinter in the pupal stage in leaf litter (Nilsson, 1978). Adults of the overwintered generation are active in April-May and those of the summer generation in July-August (Gomez-Bustillo, et al., 1980). Adults fly at night (Carter, 1984).

c. *Dasychira horsfieldi*

Embryonic development lasts 9-11 days.

Of seven larval instars, each takes 5-6, 5-6, 4-7, 4-7, 6-11, 8-15 and 8-11 days, respectively. The pupal period is 9-12 days for males and 12 to 15 days for females (Gupta, et al., 1986).

There are six larval instars in the male and seven in the female. Female pupae are larger than male pupae (Gupta, et al., 1989).

Longevity of adult females is 6-8 days and of males, 4-6 days (Gupta, et al., 1986).

d. *Dasychira mendosa*

The preoviposition period is 1-2 days; the egg stage about 5-10 days; the larval stage of six instars about 13.2 to 40.8 days; the prepupal stage about 1 to 2.8 days; and the pupal stage from 15 to 16 days. The complete life cycle lasts from 27 to 66.5 days (Mehra & Sah, 1974). Males live for 3.6 days and females for 5 days (Das, 1990; Mathavan, et al., 1984).

e. *Euproctis bipunctapex*

Started the first documented outbreak of pruritic dermatitis in Singapore. Hairs were analyzed and histamine involvement substantiated (Lee, et al., 1991).

f. *Euproctis chrysorrhoea*

This species is of special medical importance because the hairs on the larvae cause severe urticaria in man (Sterling, 1983). In the United Kingdom, it is necessary to treat fruit trees, ornamental bushes and plants along railroad embankments where the larvae occur, sometimes in very large numbers (Strand & Sylvester, 1981). In Western France, human deaths have been reported among workers in forests heavily infested with this species. The problem seems to be caused by the barbed hairs, which retain their urticating substances for several months. Since they can become detached, people working or walking in forests can pick up the hairs without contact with any larvae, and thus suffer skin irritation, damage to the eyes and to the respiratory tract. Hairs settled near the surface of the eyes can penetrate and cause serious damage several years later (Sellier, et al., 1975).

Several new biotypes, due to urbanization, now exist in Croatia along the coast and offshore islands (Novakovic, et al., 1989). The significance of these biotypes is not known.

Adults fly at night from the end of June to the end of July or beginning of August. A leaf normally carries one mass of 200-500 eggs on the lower surface. Carter (1984) however, says they lay 150-250 eggs (on twigs-in error-Schaefer-pers. comm.), covered with scales from abdominal tuft hairs of the female. The larvae skeletonize the leaves and form nests of webbed leaves, often at the tips of branches, where young larvae overwinter. In the spring, they destroy the young leaves as they move to fresh feeding sites (Carter, 1984). They pupate around the end of May from silken cocoons on the trunk or in the crown. Adults emerge in July or August (Carter, 1984). There is one generation a year (Lyashenko, 1986).

g. *Euproctis fraterna*

The larval period ranges from 4.8 days on roselle to 5 days on castor and mango and 9 days on okra. These differences are related to the water content of the hosts (Manoharan, et al., 1982). During the night, the larvae feed individually towards the ends of the branches, but before noon of the following day, have descended to the trunk and large branches congregating in the shade in dense masses (Sandhu, et al., 1977).

In a laboratory study, the development period was 40-45 days from egg to pupa. The average female lifespan was 8.5 days, during which an average of 155 eggs was laid (Mukherjee, et al., 1991).

In another study (Gurdip-Singh, et al., 1989), two types of larval population were identified in November-March: short-duration larvae which completed development in 30-57 days and long duration larvae which completed development in 99-128 days.

h. *Euproctis lunata*

Females lay from 27 to 316 eggs in paired rows of about 19 eggs (Jena, et al., 1984) from August to November. Egg viability drops late in the season. Egg duration lasts 6-22 days. Larval development ranged from 12 to 121 days depending on the season. There are six larval instars of 7, 2.3, 3.3, 3.0, 4.4, and 5 days each. Pupation takes place in a thin cocoon on the plant (Jena, et al., 1984). Pupal development ranges from 9 to 20 days, depending on the season. Adults emerge in the evening (Jena, et al., 1984). The pre-oviposition period lasts 1-3 days and the oviposition period is 1-6 days. Mated females have a longer life-span than unmated ones, but otherwise males lived 4 days and females 4.45 days respectively (Islam, et al., 1988). The whole life cycle is about 52 days (Jena, et al., 1982). Three generations can be completed between August-April (Girdip, et al., 1981b).

i. *Euproctis melania*

This species forms overwintering nests from rolled leaves of the host (i.e., oak trees - *Quercus* spp.). The average number of larvae per nest is 49.7. Parasites, especially *Apanteles* spp. (10.8 percent average rate), also overwinter in the nest as mature larvae. A few other parasites (*Pteromalus* sp.) or hyperparasites (*Pediobius pyrgo*) may also be present (Awadallah, et al., 1979).

j. *Euproctis scintillans*

The egg stage lasts 7.18 days on average. The larvae have 5 or six instars, which last 20.7 and 28.37 days respectively. The prepupal stage lasts one day and the pupal stage lasts 7.71 days on average. Adult males last for 6.93 days and females last for 6.63 days. Each female can lay, on average, 274.19 eggs (Koshiya, et al., 1977).

The larvae have been reported to feed on leaves, buds, and young fruits of apple (Chander & Dogra, 1983).

k. *Euproctis similis*

There is one generation a year. The larvae overwinter in nests on the trees. Mating peaks on the day after emergence at about 3-4 a.m. Adult males mate up to three times, females only once. Both sexes seem to fly at night (Carter, 1984). Females deposit eggs about 1-2 days after adult emergence (Pu, et al., 1985).

Eggs are laid in an elongate batch of 150-270 on the underside of leaves or twigs and covered with hairs from the anal tuft of the females. On emergence, larvae feed gregariously until autumn, when it constructs an individual hibernaculum for overwintering. In the spring, larvae become solitary feeders on newly developed foliage.

Pupation takes place in July and the adults emerge in July-August (Carter, 1984).

l. *Euproctis subnotata*

The most important lepidopterous pest of sorghum in India. Oviposition takes place after flowering. Hardening of the ears limits development time to only one generation (Mogal, et al., 1980).

The average egg incubation period is 6.7 days. The larval period is 23.57 days (27-33 days) (Jena, et al., 1984) with 6 instars. The pupal period is 11 to 16 days. The life cycle is 42.77 to 58 days. The adults emerge in the evening and live 8.5 days. Females lay an average of 113 eggs (Patel & Kulkarni, 1990) or 186 to 273 eggs (Jena, et al., 1984; (Patel & Kulkarni, 1990).

On tea, the life cycle is complete in about 8 weeks (Das & Goswami, 1977).

m. *Euproctis taiwana*

Larval development may depend on the host, in part. In mung bean, the males have 6 instars and the females 7 instars. On soybean, however, the male has 5 and the female 6 instars (Su, 1987).

The developmental periods at 25°C are 8 days for eggs, 18.5 and 23.3 days for male and female larvae respectively, and 9.9 and 10.2 days for male and female pupae respectively. The adult male lives 6 days on average and the female lives 5.83 days while laying 211.5 eggs. The threshold temperatures are 10°C for eggs, 7.9 and 9.1°C for male and female larvae and 2.5 and 10.1°C for male and female pupae respectively (Su, 1985a).

Full day degree criteria are as given below.

Euproctis taiwana (Su, 1985)

	Lower Threshold	Day Degrees
Egg:	50.0°F (10.0°C)	248 (in °F) 120(in °C)
Larva:	44.9°F (7.9°C)	603.9 (in °F); 335.5 (in °C)
Female Larva:	48.4°F (9.1°C)	652.0 (in °F); 370.0 (in °C)
Male Pupa:	54.5°F (12.5°C)	254.8 (in °F); 123.8 (in °C)
Female Pupa:	50.2°F (10.1°C)	273.2 (in °F); 151.8 (in °C)

	Total DD
Egg to Adult Male:	1024.7 DD (in °F); 569.3 DD (in °C)
Egg to Adult Female:	1155.2 DD (in °F); 641.8 DD (in °C)

n. *Gynaephora* spp.

These species are steppe caterpillars. They are important pests of forage grasses in highland pastures in NW China (Chou & Ying, 1979).

o. *Heteronygmia dissimilis*

A multivoltine species in Africa with 4 overlapping generations a year. All stages can be found much of the year, March to October. This species overwinters in the pupal stage from November to February. The life cycle from egg to adult is 41 days for males (5 instars) to 45 days for females (6 instars). Females produce 200 eggs on average.

Larvae have 2 color variations. They are generally nocturnal feeders, skeletonizing leaflets in the early instars and resting on foliage or bark during the day. Adults have sexual dimorphism in terms of size, color, and shape (Schabel, et al., 1988).

p. *Ivela auripes*

Overwinters in the egg stage. A temperature of 20°C is the optional thermal condition for the production of heavy female pupae and survival to adulthood, but development is most rapid at 30°C for larvae and at 25 to 30°C for the pupal stage (Togashi & Kodani, 1990).

q. *Leucoma (=Stilpnotia) salicis*

One (Szalay-Marzso, et al., 1981) to three generations (Cobanoglu, 1992) a year. The larvae overwinter in the 2nd instar in crevices of tree trunks, with a diapause beginning in the middle of summer (Szalay-Marzso, et al., 1981; Cobanoglu, 1992). They are covered by a web (usually individual) which are only about 4 mm long and match the color of the bark, and are thus very inconspicuous. They resume feeding in the spring and in the seventh instar, spin a loose cocoon through which the pupa is plainly visible (Ferguson, 1978).

About 10 days later, adult eclosion occurs between 8 a.m. and 11 p.m., with males emerging earlier. Female calling behavior and mating occur shortly after sunset the day of eclosion. Mating lasts for about 19 hours. Mating may be multiple for both sexes (Wagner & Leonard, 1979a).

The adult does not feed, is a poor flier and is active mainly at night. Female flight normally follows deposition of the first egg-mass, thereafter the daily flight often precedes oviposition (Wagner & Leonard, 1979a). Females usually rest on grasses and shrubs for much of the time. Males are more active and fly in search of females for considerable distances. Their flight usually starts at 5 a.m., peaks at 4-9 p.m. and ends by 1:30 a.m. the following day (Wagner & Leonard, 1979a). Mass flight occurs in early July (Gromova, 1980).

Oviposition occurs between 4-11:30 p.m. from early July to late August. The largest egg masses are the first laid. Each female lays an average of 4.6 egg masses totaling 650 eggs in frothy secretions (Wagner & Leonard, 1979a; Ferguson, 1978). Light green flattened eggs are laid in masses of 50-500 on trunks and twigs and on the lower surface of leaves or on grasses (Gromova, 1980). The one or two layered egg masses are covered in a glistening white secretion (Humphreys, 1984) and are concentrated on the sunniest part of the branches of the largest trees. The mean number of eggs per mass is greatest between 10-20 meters above the ground. Fertility is greatest in large egg masses near the center of the tree declining towards the edges (Nef, 1975). Hatching begins towards the end of July and in August-September, coinciding with full opening of the leaves (Gromova, 1980).

The life span of males average 8.6 days and females 9.4 days under field conditions (Wagner & Leonard, 1979a).

In certain years, outbreaks occur, usually on poplar and willow (Gronova, 1980). Severe defoliation has resulted in top-kill and tree mortality. Rolled leaves containing pupae and silk webbing on boles and branches and occasionally larval skins, are indicative of satin moth infestations (Humphreys, 1984).

This species is subject to attack by egg, larval, and pupal parasitoids (Cobanoglu, 1992).

r. *Leucoma wiltshirei*

Females lay about 100-130 eggs in 6-18 batches on the lower surface of leaves and twigs. The egg, larval, and pupal stages last 6-7, 42-55 and 7-8 days, respectively (Adeli, 1980). Development is fastest at an optimal temperature of 32°C and 65 percent RH (Abai, 1981).

There are 7 larval instars (Adeli, 1980). First instar larvae are solitary feeders and spin small webs for protection (Abai, 1981). Small larvae feed on the lower surface of leaves; older ones feed on leaf tissue. Overwintering of the 3rd generation (Abai, 1981) takes place in the 2nd, 3rd and early 4th instars in cracks of the bark or between shed leaves on the ground (Adeli, 1980).

This species is said to be an important pest of oak forests in Iran.

s. *Lymantria ampla*

Females lay 100-200 eggs. The larval period lasts 20 to 30 days. The pupal period lasts 14 days. On cotton, there are about 20 to 30 larvae per plant (Pramanik and Basu, 1975).

t. *Lymantria dispar*

The female lays 50-800 eggs during July to September in a hair covered mass on the tree trunk (or walls, fences, etc.). Eggs hatch the following spring. The larvae are present 6 to 12 weeks in April to July, depending on temperature. During this time, they feed at night crawling to shelter in the daytime. There is very little between-tree movement (Weseloh, 1987) until epidemic populational levels are reached, at which point inter-tree movement is much greater (Liebhold, et al., 1986). Pupation occurs in a silken cocoon spun amongst foliage. The adult emerges from July to September. The male flies by day; the female does not fly (Carter, 1984).

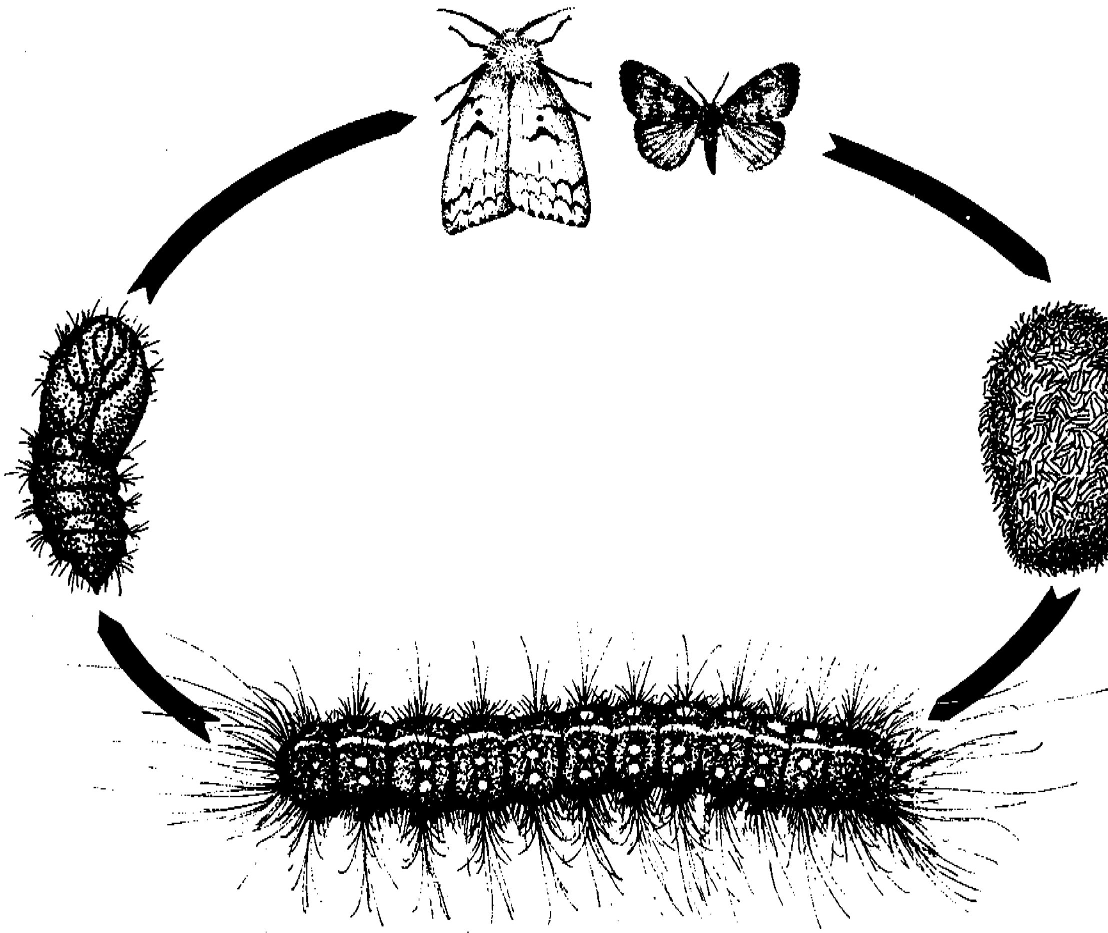
Delayed mating has been studied in this species. A delay does not affect female longevity. With increasing age, females were less likely to mate or receive a full complement of sperm than females exposed to males within the first few days after emergence. Females that oviposit before meeting males are less likely to mate. For females receiving a full complement of sperm, the number of eggs produced, the number laid, and egg viability decreased with increasing age at mating. Overall, a delay in mating of 3-5 days resulted in a reduced reproductive potential of females from 40-90 percent that of females mated within 36 hours (Proshold, 1996).

The rate of dispersal of this species has been extensively studied. It appears that male moths fly up to 68 miles (110 km) from the source of a population. The capture rate in traps range from 1 per trap at the outer limits to 10 times that number for every 18 miles (29 km) heading back to the population. It takes about 11 years for the population to catch up, as the females are flightless (Sharov, et al., 1996). Obviously, for those species where the female also flies, the rate of dispersal would be much higher, up to the flight range of the male each year, and dependent on the flight willingness and/or range of the female.

The female of an Asian strain does fly. Additionally, the Asian females are attracted to light, where they lay egg masses (Hofacker, 1994). Peak flight (Wallner, et al., 1995) is between 11 p.m. and 1 a.m. The larvae of the Asian strain also feed on some hosts that are only marginally acceptable to the European strain and thus may have a higher establishment potential and cause more extensive defoliation than the European strain (USDA, APHIS, 1992). In addition, (at least in Asia), the female oviposits on lower leaves of the host rather than on tree trunks, the eggs thus reaching the ground at leaf fall and remaining protected beneath the snow (Izhevskii, 1992).

There is also a Japanese subspecies in which the female is capable of flight and apparently flies well (Ferguson, 1978).

The Life Cycle of the Gypsy Moth



Drawing by Legislative and Pubic Affairs, APHIS, USDA

Full day degree criteria are given below.

Lymantria dispar (Carter, et al., 1992)

Lower Threshold:	45.77 °F
	7.65 °C
Upper Threshold:	105.80 °F
	41.00 °C
Day Degrees: Hatch to First Pupation	
Low:	815.4 DD (°F)
	453.0 DD (°C)
High:	1186.2 DD (°F)
	659.0 DD (°C)

u. *Lymantria marginata*

At 27.9 to 31.8°C, eggs hatch in 9-10 days. Larval females go through 7 instars over an average of 41.5 days and larval males over an average of 28 days. The pupal period averaged 8.1 days (Jasvir Singh, et al., 1986). Feeding is nocturnal, with the greatest peak 4 hours before sunrise (Goel, et al., 1986).

v. *Lymantria mathura*

Peak flight is between 1 to 3 a.m. (Wallner, et al., 1995). Females are reported to oviposit on nonhost trees such as conifers, on buildings, and on telephone poles (Zlotina, et al., 1999). Feeding in the spring by neonates is initiated on buds, thereby increasing the level of damage to the host (Zlotina, et al., 1998). In a separate study, dispersal of neonates by silken threads was estimated to far exceed those of Asian and North American Gypsy Moth. This was deemed due to a lighter neonate weight and consequently slower settling velocity which allows them to be dispersed by wind for greater distances (Zlotina, et al., 1999).

w. *Lymantria monacha*

Eggs are laid (August-April) in batches of 20-100 in crevices of the bark (Carter, 1984). This habit means that *L. monacha* has a high transport potential because females may deposit eggs in crevices on containers, pallets, and ships (Keena, et al.,1998). The eggs are able to survive repeated overwintering and still produce viable progeny. This results in a many-year embryonic diapause which may be an indicator of falling numbers (of the population) (Markov, 1989).

Larvae appear in April-July, and are gregarious when at rest, congregating in a sheltered position (Carter, 1984). First and second instars are capable of being dispersed by wind for considerable distances (Keena et al., 1998). Larvae can feed on acorns of English oak, especially when conifer needles are added. This diet can be used as food during the winter months resulting in greater larval survival and a larger number of females with greater weight and fecundity (Atanasov, 1980).

The pupa appears in July and August in a light silken cocoon in a crevice of the bark (Carter, 1984).

Adults appear from August-September. The male flies at night. The female (which can fly - Keena, et al., 1998) moves very little and usually remains on the tree trunk (Carter, 1984). The adult males respond to temperatures for nocturnal flight. Peak flight is between 15 and 20°C at dusk when light has fallen to 1-3 lux in forest stands. Flight ceases at less than 10°C. (In a statement requiring verification, Pristavko & Smirnova, 1984, state that adult flight took place only when the average nightly temperature is lower than 5°C (41°F) and the humidity is close to saturation point. Peak flight activity was observed at 1-2 a.m. Peak flight is backed by Wallner, et al., 1995, who puts this between 2-5 a.m. when *L. dispar* and *L. mathura* are present). Light traps have only one peak catch per night, but pheromone traps have two peak catches per night (Skuhravy & Zumr, 1981).

Marked male moths have been recaptured at up to 280 meters from the release site after 24 hours and at distances of up to more than 3,500 meters (2.17 miles) after 10 to 14 days. Some were still being caught up to 24 days after release, indicating they can survive in the field for almost 1 month (Skuhravy & Zumr, 1978).

x. *Lymantria obfuscata*

Overwinters in the egg stage (Singh & Lakshmi, 1987).

y. *Ocnerogyia amanda*

There are 3-4 generations a year. The larvae overwinter and emerge as adults in the spring. Females lay up to 75 eggs on the leaves or trunk of fig trees. Eggs hatch in 6 days. Larvae began to defoliate the trees in the 2nd or 3rd instar and pupate in cocoons on the leaves. Adults emerge after 7-10 days (Abai & Faseli, 1986).

z. *Orgyia antiqua*

This species overwinters in the egg stage in nests attached to dried leaves and twigs. Hatching occurs in April when early apple varieties begin to flower. The larvae spread over the tree and skeletonise the leaves at first, then damage the fruits.

They pupate on healthy leaves after 30-40 days. Pupae are in a thin cocoon of silk mixed with larval hairs, usually attached to a leaf or twig of the host (Carter, 1984).

Adults emerge 5-13 days later. The males fly off, but the females are flightless (Carter, 1984) and stay on the remains of their cocoons, where they are mated. Eggs are laid on the female cocoon after 1-3 days in masses of 135-393 eggs.

There are usually 3 generations a year. These second generation eggs appear during June-July, hatch in about a month, and give rise to larvae that feed until July-August, going through 5 instars for both sexes (Littlewood, 1984). Adults emerge in August. If there is a third generation, the adults emerge in September-October (Galetenko & Pastukh, 1980).

aa. *Orgyia gonostigma*

This species overwinters in the 2nd or 3rd larval stage. The larvae become active when the temperature reaches 8 to 10°C.

bb. *Orgyia leucostigma*

Short-range precopulatory behavior of this species includes tarsal contact by the male of the female body scales. Without these scales, male behavior is significantly altered (Grant, G.G., 1981). Female wings are reduced in size, but still reasonably proportioned; male wings are of normal size (Nardi, et al., 1991).

Cocoons are spun on the exposed bark of the bole (29.6 percent), in crevices on the bole formed by pruning (17.5 percent), beneath limbs (24.2 percent), and in branch crotches (28.7 percent) of black walnut. Parasites and predators destroy 88% of the pupae. Other parasites, etc., destroy larval stages (Wilson, 1991).

cc. *Orgyia postica*

Females have four molts during the larval period and one instar more than males. However, female pupal development is accelerated compared to that of males so that they emerge about the same time (Gu, et al., 1992).

The number of instars may depend on the host. In mung bean, the male has five instars and the female has six instars. On soybean, the male has four instars and the female five instars (Su, 1987).

The developmental periods of eggs at 25^{0}C is 7 days; for male larvae, 19.43 days, for female larvae, 24.7 days; for male pupae, 8.32 days, and for female pupae, 5.6 days. The adult female lives 4.56 days during which she lays 152 eggs; the male lives 5.3 days. Threshold temperatures are 11.8^{0}C for eggs; 5.8 and 5.1 days for male and female larvae, respectively; and 11.2 and 15.1^{0}C for male and female pupae (Su, 1985a).

Full Day Degree criteria are given below:

Orgyia posticus (Su, 1985)

	Lower Threshold:	Day Degrees
Egg:	53.3°F (11.8°C)	197.8°F (92.1°C)
Male Larva:	42.5°F (5.8°C)	702.8°F (372.7°C)
Female Larva:	41.2°F (5.1°C)	916.7°F (491.5°C)
Male Pupa:	52.2°F (11.2°C)	237.3°F (114.0°C)
Female Pupa:	59.1°F (15.1°C)	132.6°F (55.9°C)

Total Day Degrees (DD)

Egg to Adult Male:	1073.8 DD(°F)	578.8 DD(°C)
Egg to Adult Female:	1183.0 DD(°F)	639.4 DD(°C)

dd. *Orgyia pseudotsugata*

Males and females are capable of mating more than once. Oviposition occurs ½ to 3 hours after mating. Egg laying may be interrupted to mate again. Females live for up to 7 days, but attract fewer males after 3 days; successful mating declines after only 1 day (Swaby, et al., 1987).

The majority of the eggs (65 percent) hatch between 800 and 1600 hours, most of these (45.8 percent) between 800 and 1200 hours. Hatching, at a rate of 20.5 percent, is complete in 9 days, with a peak at 4 days after first hatch (Edmonds, 1979). Larvae first start feeding by bud burst in the spring, thus bud burst is a good index of this event (Wickman, 1976).

Peak larval movement occurs 3 days after peak hatch (Edmonds, 1979). Dispersal occurs by means of silken threads spun by the 1st (6 percent) and 2nd instars (4 percent) for aerial transport. Drift, over a period of 10-20 days, is mainly to adjacent stands during morning daylight hours before noon (Mitchell, 1979).

Newly hatched larvae of this species can survive lower temperatures under conditions of starvation (Beckwith, 1983). When populations are high, predation by insects and spiders reduce the first larval instars and birds the older instars. The combined effect is about 47.2 percent, as measured in a study by Mason and Torgersen, 1983. Outbreaks generally occur in relatively open stands of white fir (*Abies concolor*), on poor sites, ridge tops, and upper slopes (Williams, et al., 1979). Dispersal and starvation also play a role in population collapses (Mason, 1981a), as well as a drop in fecundity as measured by a drop in egg production (Mason, et al., 1977).

Female pupae appear to be concentrated in the bottom third of the live crown of the host and are more heavily parasitized than the male (Luck & Dahlsten, 1980).

Mean development time at constant temperatures varies from 127.4 days at 15°C to 43.4 days at 30°C; 22 to 26°C appear to be the best rearing temperatures (Beckwith, 1982). The threshold temperature is 5.6°C (Edmonds, 1979). On an experimental basis, eggs were stored for 210 days at a temperature of 4.5°C which gave a % hatch equal to normal conditions (Beckwith & Stelzer, 1979).

While this species is generally considered a serious pest of forests, at least one study suggests that it "plays a key role as a phytophagous regulator of primary production in some second-growth white fir stands in California and elsewhere" (Wickman, 1978).

ee. *Orgyia thyellina*

Diapause may occur in the egg stage and is determined by the photoperiod of the female parent in its larval stage. Diapause eggs are heavier and thicker, with a thicker chorion than that in non-diapause eggs.

Female larvae usually molt 5 times and male larvae 4 times.

The wing form of adult females varies, depending on the photoperiod of the larvae. A short photoperiod meant the adult female was brachypterous, a long photoperiod meant that the adult female was macropterous (Sato, 1977). Seasonal variations in the wing form appear to be adaptations to weather conditions. In the summer, the adults emerge in the afternoon and mate at dusk. In the autumn, emergence takes place any time between sunrise and sunset and females begin calling shortly after emergence as cold night temperatures may not be suitable for the male (Sato, 1978).

The development threshold for the summer generation is 10.1°C and the thermal constant is 665 day degrees. There are 2-3 generations a year, depending on location (Sato, 1977).

Full day degree criteria are given below.

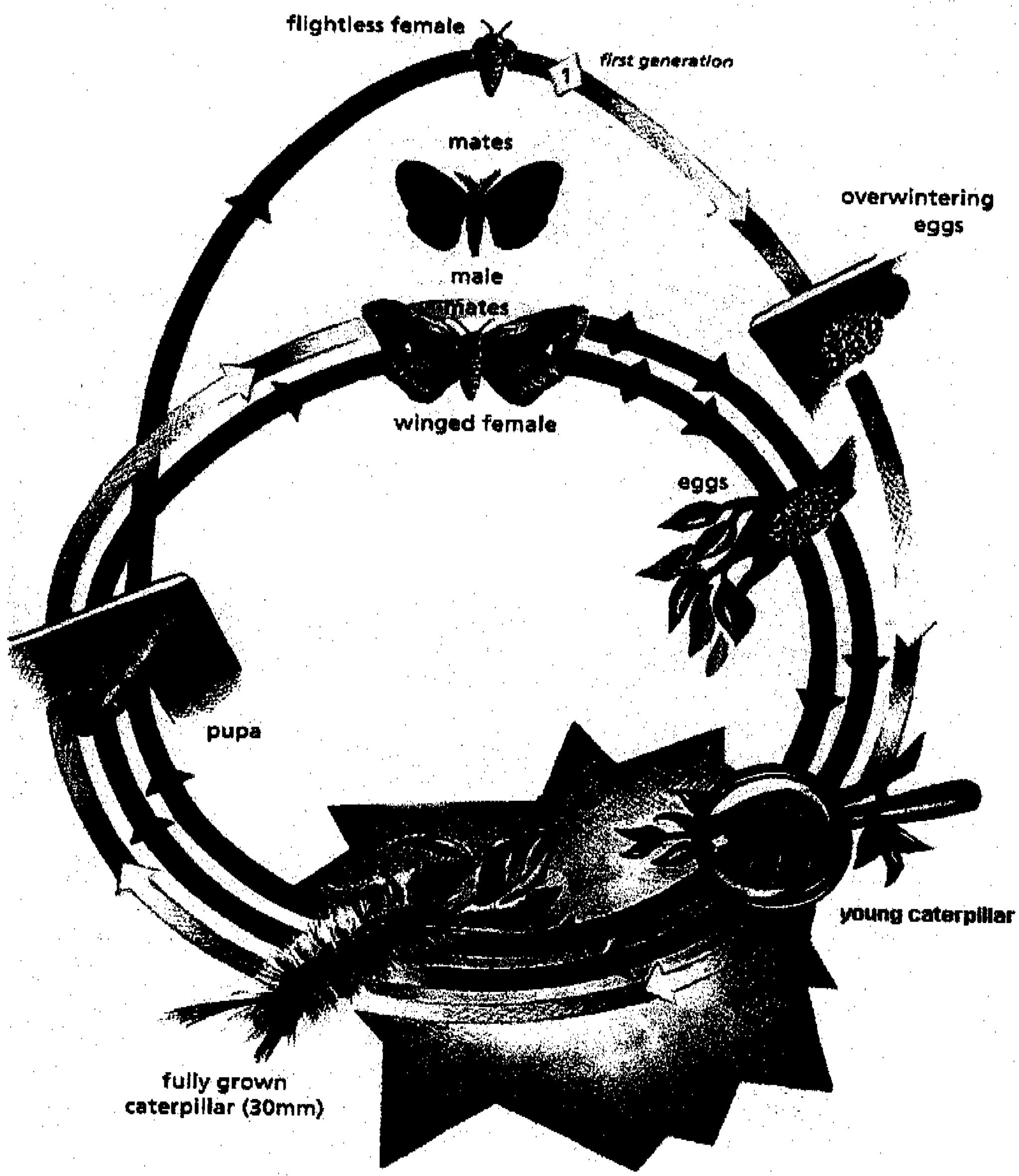
Orgyia thyellina (Sato, 1977)

Lower Threshold:	50.18 °F 10.1 °C
Alternate Threshold:	50.75 °F 10.4°C

<u>Total DD per Generation</u>

Low:	1155.2 DD (°F) 624 DD (°C)
High:	1229.0 DD (°F) 665 DD (°C)

Life cycle of the white-spotted tussock moth



ff. *Pantana sinica*

There are 3 generations a year. This species overwinters in the pupal stage in gaps and crevices under stones or in thickets. Larvae from the first generation climb the culms in May. The first generation is present from mid-April to early August; nearly all males are black and white. The second generation appears from late June to early October; all males are black. The third generation is from mid-September to early December; the proportion of black/white to black is 8:1. Mature larvae begin spinning cocoons and pupating in early December (Wei, 1984).

Eggs hatch in 15 days in the first generation, but only 6-7 days in the second generation during the year (Wei, 1987).

<u>Predators and Parasites</u>:

While not strictly predators, certain flesh-eating flies (Sarcophagidae) may consume dead larvae. If the larvae have died as a result of an epizootic, the disease may be spread by these flies. Zhu, et al., 1980, studied such results in China on *Dasychira locuples*, and observed that a polyhedra of a virus, DlMNPV, adhered to the mouthparts and appendages of large numbers of flies feeding on the dead larvae.

<u>Entomopathogens</u>:

The literature is replete with many entomopathogens of lymantriids. The main groups are:

Bacteria (*Bacillus* spp., *Enterobacter* sp.),

Viruses (many Nuclear Polyhedral Viruses, Cytoplasmic Viruses, and a few odd ones like *Nuraurelia* sp. and a *Borrelinavirus* sp.),

Protozoa (*Pleistophora* spp., *Vairimorpha* sp., *Nosema* spp. and an unknown microsporidium),

Nematodes (*Heterorhabditis* sp.), and

Fungi (*Empusa* sp., *Entomophthora* spp., *Beauveria* spp., *Paecilomyces* spp., *Verticillium* sp., *Metarhizium* spp., *Hirsutella* sp., *Fusarium* spp., *Entomophaga* sp.).

Those entomopathogens known to date are listed in Control Procedures.

Natural Protection:

Eggs are usually protected by silken webbing and other materials. Larvae may also spin silken webbing and/or hide themselves under bark or similar shelter. Pupae are found in cocoons. Adult males usually match their natural background coloration and pattern and thus are hard to see.

ADDENDUM 8

Forms

Forms, as developed by the State, may be listed in this section.

ADDENDUM 9

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ADDENDUM 10

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