DISCUSSION OF LBAM ERADICATION PROGRAM

SOME BIOLOGICAL ATTRIBUTES OF LBAM

- Over a 14 day period in October we trapped 523 males which could represent up to 523 females that could lay 2.6 to 4.4 million eggs over their 2 to 3 week life span.

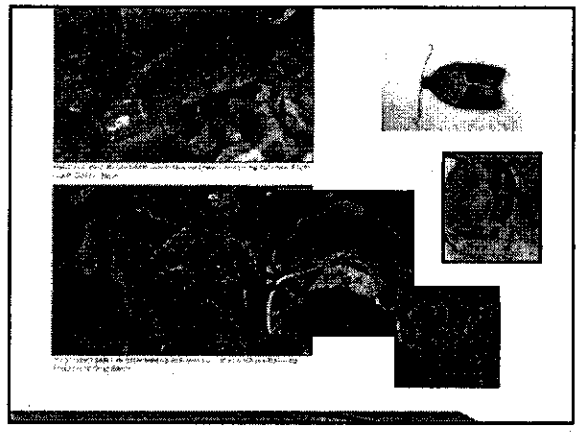
SOME BIOLOGICAL ATTRIBUTES OF LBAM

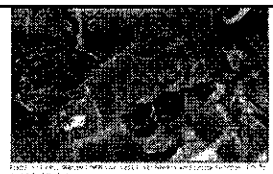
- A single female can give rise to over 1 billion offspring per year if all survive. Even if 90% die, a single female can still give rise to over 1 million offspring per year.
- Each male trapped represents up to 16.7 males in the population. There is a 1:1 sex ratio so each trapped male also may represent up to 16.7 females.

SOME BIOLOGICAL ATTRIBUTES OF LBAM

- Larvae eat some 2000 types of plants. Most are common plants in our gardens, parks, forests and crop lands
- The moths develop at temperatures above 45.5 °F. This means continuous development in much of the state. There are up to 4 generations possible per year.
- Females can lay 300-500 or more eggs each.

LBAM LIFE CYCLE AND STAGE SUSCEPTIBILITY TO ERADICATION TOOLS





DESCRIPTION OF TOOLS CONSIDERED FOR USE IN LBAM ERADICATION PROGRAM

- **Tool: Foliar Sprays of Synthetic In secticides**
- **Description of tool:** Synthetic insecticides are sprayed on plants. LBAM larvae are killed by contacting the insecticides and/or ingesting them while eating treated foliage. Full coverage of target plants is necessary.
- **Examples of tool use:** A number of synthetic insecticides are recommended for use against LBAM in New Zealand and Australia.
- **Applicable to LBAM Eradication Pro gram:** Synthetic insecticides could be incorporated immediately into the LBAM eradication program. There are ground and aerial technologies available for the application of these insecticides.

- **Tool: Foliar Sprays of Bo tanical Insecticides**
- **Description of tool: Botanical insecticides are sprayed on plants. LBAM larvae are killed by ingesting them while eating treated foliage. Full coverage of target plants is necessary.**
- **Examples of tool use: Several botanical insecticides are recommended for use against LBAM in New Zealand and Australia.**
- **Applicable to LBAM Eradication Pro gram: Botanical insecticides could be considered for incorporated into the LBAM eradicatio n program. There are ground and aerial technologies available for the application of these insecticides.**

- **Tool: Foliar Sprays of Insec t Growth Regulators**
- **Description of tool:** Insect Growth Regulators are sprayed on plants. LBAM larvae ingest them while eating treated foliage. Exposed larvae are unable to molt or develop properly. Full coverage of target plants is necessary.
- **Examples of tool use:** Several Insect Growth Regulators are recommended for use against LBAM in New Zealand and Australia.
- **Applicable to LBAM Eradication Pro gram:** Insect Growth Regulators could be incorporated immediately into the LBAM eradication program. There are ground and aerial technologies available for the application of these insecticides.

- **Tool: Foliar Sprays of Insec t Pathogens**
- **Description of tool: Insect pathogens are sprayed on plants. LBAM larvae ingest them while eating treated foliage. Exposed larvae are killed by infection of the pathogen. Full coverage of target plants is necessary.**
- **Examples of tool use: Bacillus thuringiensis recommended for use against LBAM in New Zealand and Australia.**
- **Applicable to LBAM Eradication Pro gram: Bacillus thuringiensis was used in early treatments of outlier infestations before mating disruption was available. Bacillus thuringiensis could be immediately re-incorporated into the LBAM eradication program. There are ground and aerial technologies available for the application of this insecticide.**

- **Tool: Foliar Sprays of Biopesticides**
- **Description of tool:** Biopesticides (Spinosad) are sprayed on plants. LBAM larvae are killed by ingesting them while eating treated foliage. Full coverage of target plants is necessary.
- **Examples of tool use:** Spinosad is recommended for use against LBAM in New Zealand and Australia.
- **Applicable to LBAM Eradication Pro gram:** Biopesticides could be incorporated immediately into the LBAM eradication program. There are ground and aerial technologies available for the application of this insecticide.

- **Tool: Inundative Releases of Parasites**
- **Description of tool:** Large numbers of parasites are released to temporarily reduce pest numbers. Typically used in situations where existing natural enemies are unable to reduce pest numbers to tolerable levels. Inundative releases must be periodically repeated to provide long-term control.
- **Examples of tool use:** Trichogramma wasps are used against LBAM in Australian crops.
- **Applicable to LBAM Eradication Pro gram:** If effective, the CDFA and USDA will need to determine how best to integrate this tool into the LBAM e radication program.

- **Tool: Inundative Releases of Predators**
- **Description of tool:** Large numbers of generalist predators are released in an effort to temporarily reduce pest numbers. Typically used in situations where existing natural enemies are unable to reduce pest numbers to tolerable levels. Inundative releases must be periodically repeated to provide long-term control.
- **Examples of tool use:** Predatory mites, green lacewings and lady bird beetles are commonly used in inundative release programs.
- **Applicable to LBAM Eradication Pro gram:** It is unlikely that generalist predators would be an effective tool in LBAM eradi cation. These predators eat the most common food sources first and will not focus on LBAM.

- **Tool: Classical Biol ogical Control- Parasites**
- **Description of tool:** Parasites are imported into California and released. If they establish b reeding populations, it is hoped that they will permanently reduce target pest numbers below damaging levels. Smaller numbers of parasites are released than in inundative releases and once the parasites are established, releases cease. Biological control agents do not eradicate the target pest.
- **Examples of tool use:** The CDFA has had several recent successful biological control programs using parasites including pink hibiscus mealybug and ash whitefly.
- **Applicable to LBAM Eradication Pro gram:** If eradication is unsuccessful, biological control is the next [illegible] are [illegible] number of parasitic wasps that

- **Tool: Classical Biol ogical Control- Predators**
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- **Examples of tool use:** The CDFA has had several successful biological control programs using predators including cottony cushion scale.
- **Applicable to LBAM Eradication Pro gram:** If eradication is unsuccessful, biological control is the next option. However, the use of parasitic wasps appears to offer a greater probability of success than the use of [illegible]

- **Tool: Mass Trapping**
- **Description of tool:** Large numbers of traps, baited with a strong lure are placed in an effort to catch sufficient target pests to reduce the population. Works best when there is a lag between adult emergence and sexually active during which the adults are attracted to the lure. Either a n insecticide or a sticky insert is used in the trap.
- **Examples of tool use:** CDFA has used mass trapping in its melon fly and gypsy moth eradication programs. Mass trapping has been researched as a pest control method, but it has little use in commercial agriculture.
- **Applicable to LBAM Eradication Pro gram:** LBAM are able to mate within minutes to hours of adult emergence. It is unclear how many traps per unit area would be [illegible] in placing and [illegible]

- **Tool: Mating Disruption**
- **Description of tool:** An area is saturated with the sex pheromone of the target pest preventing the male insects from finding females. Unmated females lay no eggs or lay infertile eggs.
- **Examples of tool use:** Mating disruption is used against codling moth, oriental fruit moth and gypsy moth. Mating disruption has been used successfully to control LBAM in New Zealand.
- **Applicable to LBAM Eradication Pro gram:** Mating disruption is the primary tactic being used against LBAM in the California eradication program.

- **Tool: Attract and Kill**
- **Description of tool:** A lure is used to draw the target insect to it where the insect dies after either feeding on the insecticide-lure mixture or crawling over the insecticide-lure mixture.
- **Examples of tool use:** The CDFA uses attract and kill (male annihilation) as the primary eradication tool for the oriental fruit fly. This tactic is being developed for other moth pests including the codling moth.
- **Applicable to LBAM Eradication Pro gram:** Attract and kill technology likely will be a useful tool in the LBAM eradication program. There are operational questions about how to apply the material and how best to integrate the tactic with other tools

- **Tool: Mobile Mating Disruption**
- **Description of tool:** An unrelated insect is used to saturate an area with the sex pheromone of the target pest. This prevents the male insects from being able to find females and mate. The unmated females either lay no eggs or infertile eggs.
- **Examples of tool use:** This is a novel concept that is only now being developed by USDA , Australian and New Zealand researchers.
- **Applicable to LBAM Eradication Pro gram:** If effective, mobile mating disruption may be a useful addition to the tools used against LBAM as alternative way to deliver the pheromone for mating disruption.

- **Tool: Trap Plants**
- **Description of tool:** Trap plants are highly attractive to the target pest. They are planted near the crop to be protected and the target pest congregate in them. The trap plants are then treated with an insecticide to kill the target pest.
- **Examples of tool use:** Trap plants are used against lygus bugs to protect cotton and against melon fly females to protect zucchini.
- **Applicable to LBAM Eradication Pro gram:** It is unlikely that trap plants would be effective as a tool for the LBAM eradication program. LBAM moths feed on over 2000 different types of plants but they have not shown the strong preference to a limited number of these that would be necessary for them to act as trap plants.

- **Tool: Physical Removal of LBAM Life Stages**
- **Description of tool:** This requires the removal and destruction of LBAM life stages (egg masses and larvae). Workers would visually inspect all vegetation looking for LBAM egg masses and larvae and they would remove and destroy any found.
- **Examples of tool use:** Hand removal is limited to small plots and larger or immobile pests including tomato hornworms on homegrown tomato and leaf rollers on homegrown blueberries.
- **Applicable to LBAM Eradication Pro gram:** It is unlikely that physical removal of LBAM life stages would be an effective tool for LBAM eradication. Visual surveys will not find all the LBAM, especially in tall trees and dense foliage. There would be considerable [illegible] as teams of workers [illegible] looking for LBAM.

- **Tool: Host removal**
- **Description of tool:** This would require the removal and destruction of all LBAM host plants.
- **Examples of tool use:** Removal of a pest's host plants is used to create a pest free zone by limiting the ability of the pest to traverse the host free area. Host removal is often used in conjunction with other tools including pesticide sprays. Host removal is a key part of Florida's Caribbean fruit fly program for the export of grapefruit.
- **Applicable to LBAM Eradication Pro gram:** It is unlikely that physical removal of LBAM host plants would be effective as a tool for the LBAM eradication program. LBAM moths feed on over 2000 different types of plant including trees, shrubs and ground covers. The removal of all hosts would create large areas denuded of [illegible]

- **Tool: Repellents**
- **Description of tool:** There are materials that can be applied to plants that will repel pest insects from landing on them and then laying eggs or feeding. Repellents are used to protect crops from attack by affected pests. They do not kill the pest nor do they reduce pest numbers. They force the pests into adjacent areas away from the treated plants.
- **Examples of tool use**: Kaolin clay can be used against leafhoppers on apples. Neem extracts can be used on many crops.
- **Applicable to LBAM Eradication Pro gram**: Repellents have little use in the LBAM eradication program. They will not reduce LBAM numbers and may enlarge the infested area by driving the pest away from treated sites.

- **Tool: Integrated Pest Management (IPM)**
- **Description of tool:** The use of one or more tools to prevent pest numbers from reaching economically damaging levels. The keys to a successful Integrated Pest Management program are monitoring pest numbers, establishing a treatment threshold level to trigger actions that will prevent economic damage, selecting the appropriate tactic to prevent pest numbers from reaching economically damaging levels and recognizing that often some crop damage is acceptable.
- **Examples of tool use**: IPM is used in nearly all crop systems in California.
- **Applicable to LBAM Eradication Pro gram**: The LBAM program uses the key concepts of IPM. Where IPM *controls* pest numbers and believes that *some damage* [illegible] *eradicating* the pest *to* [illegible] *LBAM.*

- **Tool: Inherited Sterility**
- **Description of tool:** In moths, partially sterilized males when mated to fertile females produce completely sterile offspring. These offspring can mate with fertile moths and the resulting eggs are nearly all sterile.
- **Examples of tool use**: Inherited sterility is still a concept that has limited use in pest control. The requirement that the target pest be allowed to breed and develop crop eating larvae for one generation before seeing results has delayed its use in commercial agriculture.
- **Applicable to LBAM Eradication Pro gram**: Inherited sterility could be a useful tactic against LBAM. Fewer mass reared moths would be needed compared to sterile moth release.

- **Tool: Sterile Moth Release**
- **Description of tool:** Sterile moths are released over an area in numbers great enough to ensure that all or nearly all wild female moths mate with sterile male moths. The resulting eggs are sterile.
- **Examples of tool use**: The CDFA successfully uses sterile fly releases against the Mediterranean and Mexican fruit flies and sterile moths against the pink bollworm.
- **Applicable to LBAM Eradication Pro gram**: Sterile moth release would be a useful tactic against LBAM. More mass reared moths would be needed compared to the inherited sterility technique.

- **Tool: Quarantines and Hold Notices**
- **Description of tool:** Governments use quarantines and hold notices to prevent the human-aided movement of pests and/or items likely to harbor the pest into their jurisdiction or the movement of pests from infested areas into uninfested areas within their jurisdiction.
- **Examples of tool use**: The CDFA maintains a number of quarantines exclude unwanted pests. The Department also uses hold notices to prevent the intra-state movement of pests.
- **Applicable to LBAM Eradication Pro gram**: Regulatory actions only prevent the human-aided movement of unwanted pests. They do not reduce pest numbers or the ability of the pest to spread on its own.

PROCESS USED BY CDFA TO SELECT TOOLS TO BE USED IN INSECT ERADICATION PROGRAMS

BASIC CRITERIA

- The CDFA uses known effective tools to eradicate exotic insects that have developed breeding populations in the state.
- The Department does not use experimental or hypothetically effective tools in its eradication programs.

BASIC CRITERIA

- If the program involves the application of insecticides to residential properties, the Department prefers to use materials registered for use by homeowners.
- Given equal efficacy and operational constraints, the Department will use the least environmentally disruptive tool in its eradication programs

TOOL SELECTION GUIDELINES

- Has there been a successful eradication program of this type of insect elsewhere?
- Are there effective control measures for the target pest or closely related species?

TOOL SELECTION GUIDELINES

- Are these tools available for use in California?
- Are these tools likely to be effective if used in California?
- Are there environmental circumstances that will likely limit the effectiveness or operational aspects of the tools? Especially important as we generally eradicate invading insects in urban settings.

TOOL SELECTION GUIDELINES

- Are there operational constraints that will limit the effectiveness of the tools?

POTENTIAL TOOLS FOR LBAM ERADICATION

- Synthetic Insecticides
- Botanical Insecticides
- Insect Pathogens
- Insect Growth Regulators
- Biopesticides
- Mass Trapping
- Mating Disruption
- Attract and Kill
- Sterile Insect Technique
- Mobile mating Disruption
- Classical Biocontrol
- Inundative Releases
- IPM
- Regulatory Control
- Trap Plants
- Hand Removal
- Host Removal
- Repellents
- Inherited Sterility

AVAILABLE TOOLS FOR LBAM ERADICATION

- Synthetic Insecticides
- Botanical Insecticides
- Insect Pathogens
- Insect Growth Regulators
- Biopesticides
- Mass Trapping
- Mating Disruption
- IPM- An approach not a tactic
- Regulatory Control
- Trap Plants
- Hand Removal
- Host Removal
- Repellents

EFFECTIVE TOOLS FOR LBAM ERADICATION

- Synthetic Insecticides
- Insect Pathogens
- Insect Growth Regulators
- Biopesticides
- Mating Disruption

POTENTIAL MATERIALS WITHIN EACH TOOL

- Synthetic Insecticides
  - Carbaryl
  - Guthion
  - Methyl Parathion
  - Permethrin
  - Diazinon
  - Fenoxycarb
  - Indoxacarb
  - Chlorpyrifos
  - Fenthion
  - Methomyl

POTENTIAL MATERIALS WITHIN EACH TOOL

- Insect Pathogens
  - Bacillus thuringiensis
  - Nuclear Polyhedrosis Virus
- Insect Growth Regulators
  - Dimilin
  - Methoprene
  - Tebufenozide
- Biopesticide
  - Spinosad
- Mating Disruption Applicators
  - Flakes
  - Twist ties
  - Microencapsulated
  - Inert carrier
  - Puffers

PROGRAM CONSTRAINTS

- The Department prefers that any insecticide used in residential areas be registered for use by homeowners. Use the most efficacious and least environmentally damaging insecticide.
- LBAM feeds on plants from ground cover to tree tops. Any material must cover all this foliage. This would require both aerial and ground sprays of any insecticide.

AVAILABLE MATERIALS WITHIN EACH TOOL

- Synthetic Insecticides
  - Carbaryl
  - Permethrin

AVAILABLE MATERIALS WITHIN EACH TOOL

- Insect Pathogens
  - Bacillus thuringiensis
- Mating Disruption Applicators
  - Twist ties
  - Microencapsulated
- Biopesticides
  - Spinosad

COMMENTS ABOUT CANDIDATE INSECTICIDES

- Bacillus thuringiensis—no contact toxicity; fewest non-target issues but will kill other caterpillars; used in California against gypsy moth; need good coverage
- Spinosad—little contact toxicity; broader range of non-target issues; need good coverage
- Carbaryl/ Permethrin—high contact toxicity; greatest non-target issues; carbaryl used in California against gypsy moth, glassy-winged sharpshooter, Diaprepes root weevil and Japanese beetle meradication programs; fewer coverage problems
- **SELECT: Bacillus thuringiensis**

COMMENTS ABOUT CANDIDATE PHEROMONE DELIVERY SYSTEMS

- Twist ties—availability issues to treat large areas; high personnel needs to treat large areas; need to recover spent units; coverage problems in urban setting, may be used in small sites
- Microencapsulated—available; easier to apply; better coverage in urban setting
- **SELECT: Microencapsulated**

COMMENTS ABOUT Bacillus thuringiensis VERSUS MATING DISRUPTION

- The pheromone will cover the entire treated area and reach all LBAM males. Will affect closely related moth males--mostly other pest species.
- The Bacillus thuringiensis sprays are not as effective at reaching all LBAM larvae due to coverage issues and the leafrolls in which the larvae hide. Will kill other caterpillars including monarch butterfly, Smith's blue, mission blue and San Bruno elfin if exposed to pathogen
- **SELECT: MATING DISRUPTION**

ACTIONS TAKEN BY CDFA TO INCREASE THE THE TOOLS AVAILABLE FOR USE AGAINST LBAM

GOAL

- The CDFA is actively working to increase the tools available for use in the LBAM eradication program.
- Having additional tools will increase program flexibility and allow program managers to better handle unique situations such as discovering LBAM within the range of a threatened or endangered insect.
- Having additional tools in the tool box does not mandate that they be used.

TOOLS BEING DEVELOPED

- Attract and Kill
- Inundative Release of Parasites
- Classical Biological Control
- Mobile Mating Disruption
- Alternative Pheromone Carriers for Mating Disruption
- Inherited Sterility
- Sterile Insect Technique

ATTRACT AND KILL

- Steps Accomplished
  - -Met with a company that has developed and successfully used this tool to control moth pests
  - -Requested that they apply for USEPA and CalEPA registration of this tool for LBAM
- Future Actions
  - -Await USEPA and CalEPA registration of the tool begin to determine how this tool might be used in the program including potential environmental effects

INUNDATIVE RELEASE OF PARASITES

- Steps Accomplished
  - -Work with USDA to establish an LBAM colony in Albany in containment
  - -Determined which Trichogramma species are commercially available in California
- Future Actions
  - -Test ability of the Trichogramma to parasitize LBAM eggs and produce viable adult offspring in containment

CLASSICAL BIOLOGICAL CONTROL

- Steps Accomplished
  - -Work with USDA to establish an LBAM colony in Albany in containment
  - -Contacted Australian scientists about supplying LBAM parasites
- Future Actions
  - -Collaborate with University of California scientist to conduct non-target tests of LBAM parasites in quarantine
  - -Apply for USDA permit to import the parasites to quarantine facility

MOBILE MATING DISRUPTION

- Steps Accomplished
  - -Work with USDA to establish LBAM colony in Hawaii
  - -Help establish collaboration between USDA and New Zealand and Australian researchers to pursue this tool
- Future Actions
  - -Determine insect to carry LBAM pheromone

MOBILE MATING DISRUPTION

-Conduct proof of concept experiments

-determine release rate of carrier insects to achieve population reduction and eradication

ALTERNATIVE PHEROMONE CARRIERS FOR MATING DISRUPTION

- Steps Accomplished
  - -Contacted several companies about their products
- Future actions
  - -Review the available products
  - -Evaluate their usefulness in program including potential environmental effects

INHERITED STERILITY

- Steps Accomplished
  - -Work with USDA to establish LBAM colony in Hawaii
  - -Help establish collaboration between USDA and New Zealand and Australian researchers to pursue this tool
- Future Actions
  - -Determine radiation dose necessary to produce partial sterility in moths
  - -Conduct proof of concept experiments

STERILE INSECT TCHNIQUE

- Steps Accomplished
  - -Work with USDA to establish LBAM colonies in Hawaii
  - - Inspected pink bollworm rearing and release operations to determine what technology might be useful in the mass rearing of LBAM with USDA, Australian and New Zealand scientists
  - -Help establish collaboration between USDA and New Zealand and Australian researchers to pursue this tool

STERILE INSECT TECHNIQUE

- Future actions
  - -Determine radiation dose necessary to sterilize moths
  - -Begin proof of concept experiments