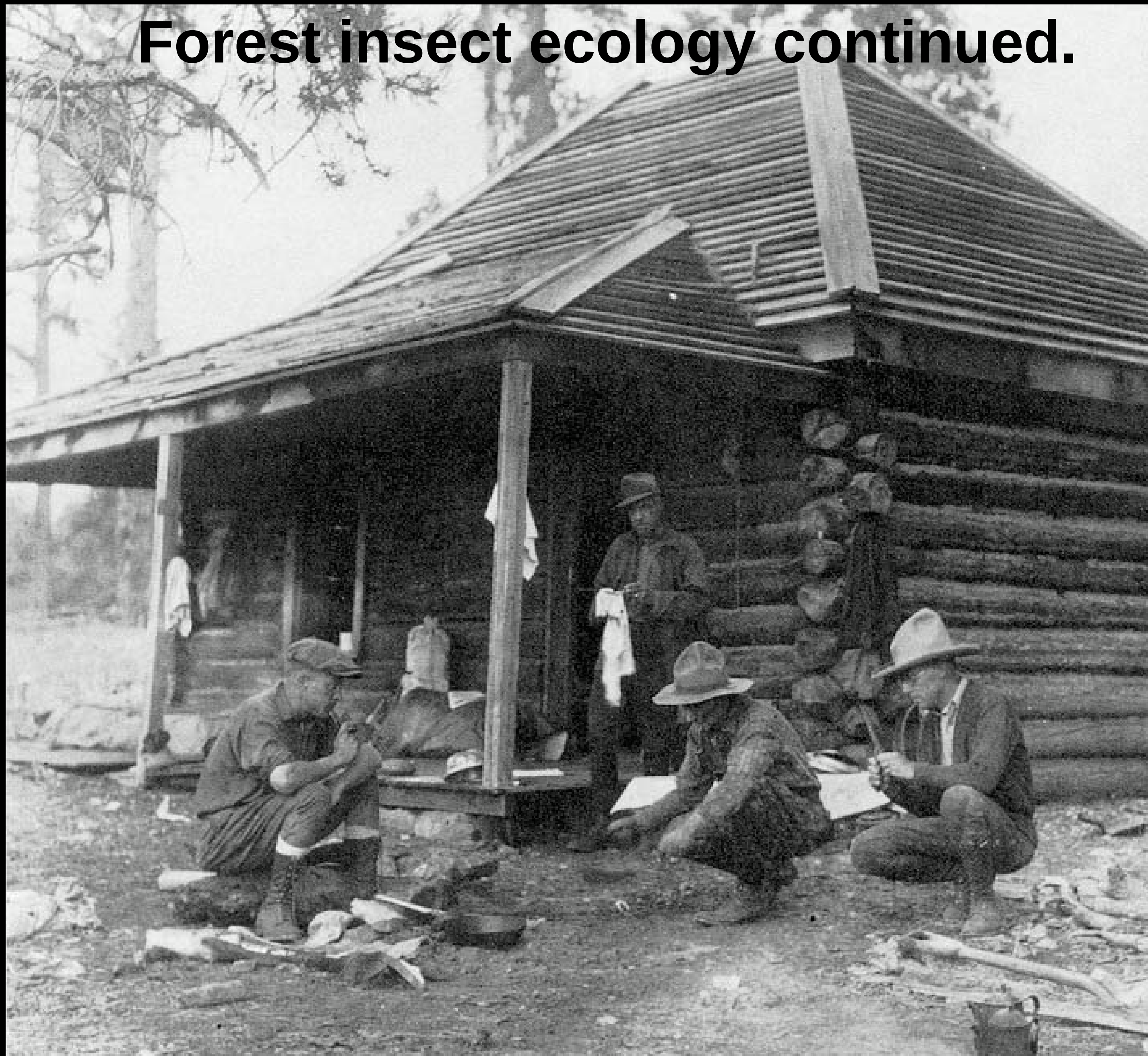
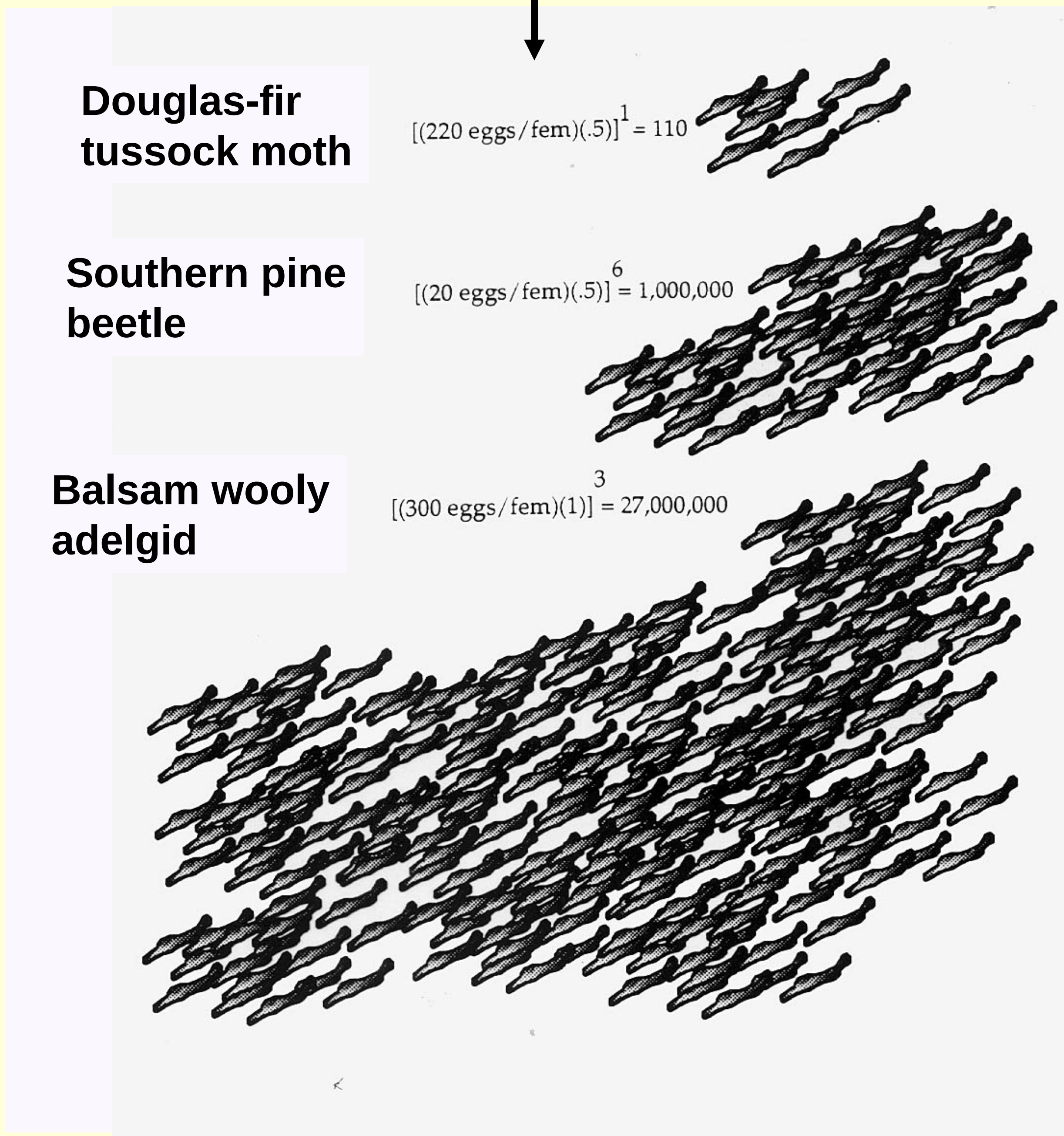
Forest insect ecology continued.



Review: The Reproductive Potential of 3 forest insects.

$$Rp = [(\text{fecundity})(SR)]^n$$



So, we've discussed two major aspects of forest insect ecology: (1) the ability of insects to reproduce rapidly and (2) mortality factors aka. "Environmental Resistance."

Mortality factors work against the Rp:

1. ~~**Physical: weather, moisture, light**~~

2. ~~**Nutritional: qualitative and quantitative**~~

3. **Biotic: natural regulation by living factors**

Biotic Mortality Factors

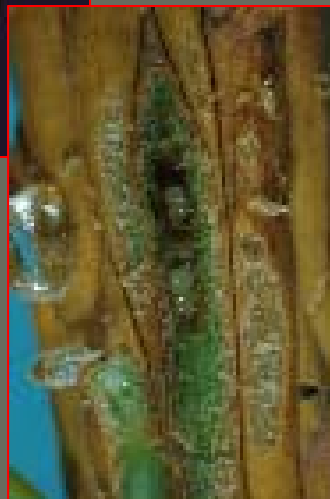
Biotic mortality factors – the interaction of competing species for limited resources. These mortality factors occur as species compete among themselves (intra-) or competition with other species (inter-).

Two cases:

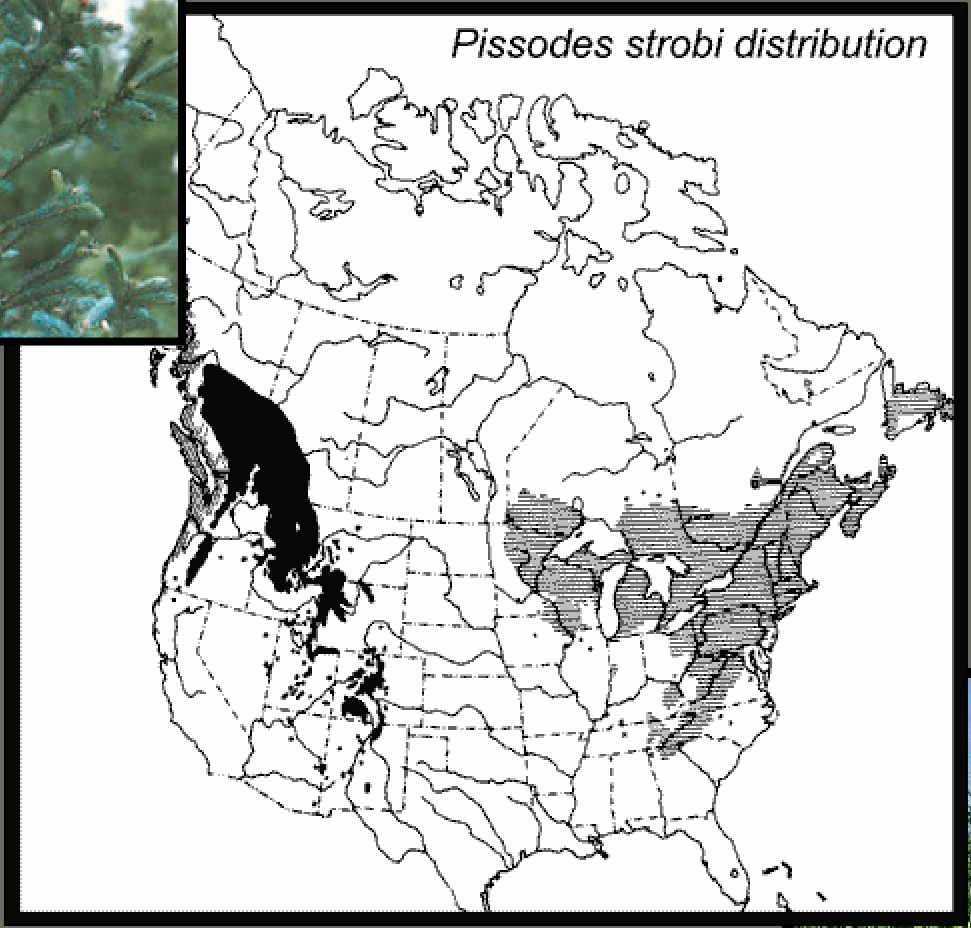
1. The Sitka spruce tip weevil, *Pissodes strobi.*

2. The Douglas-fir beetle, *Dendroctonus pseudotsugae*.

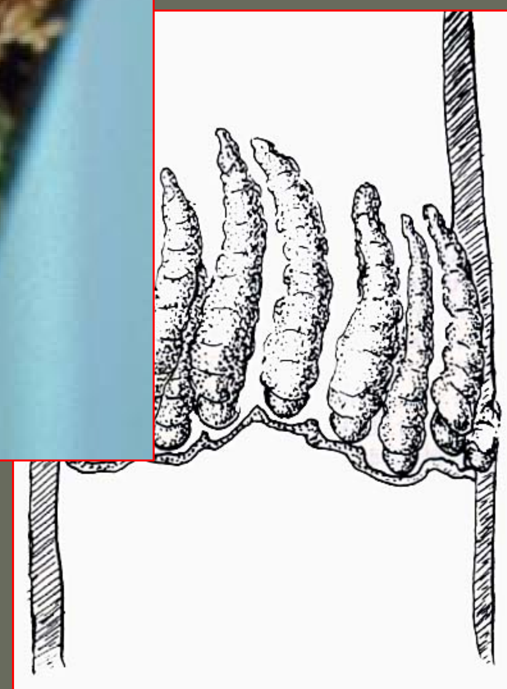
Sitka spruce tip weevil/white pine weevil, *Pissodes strobi.*

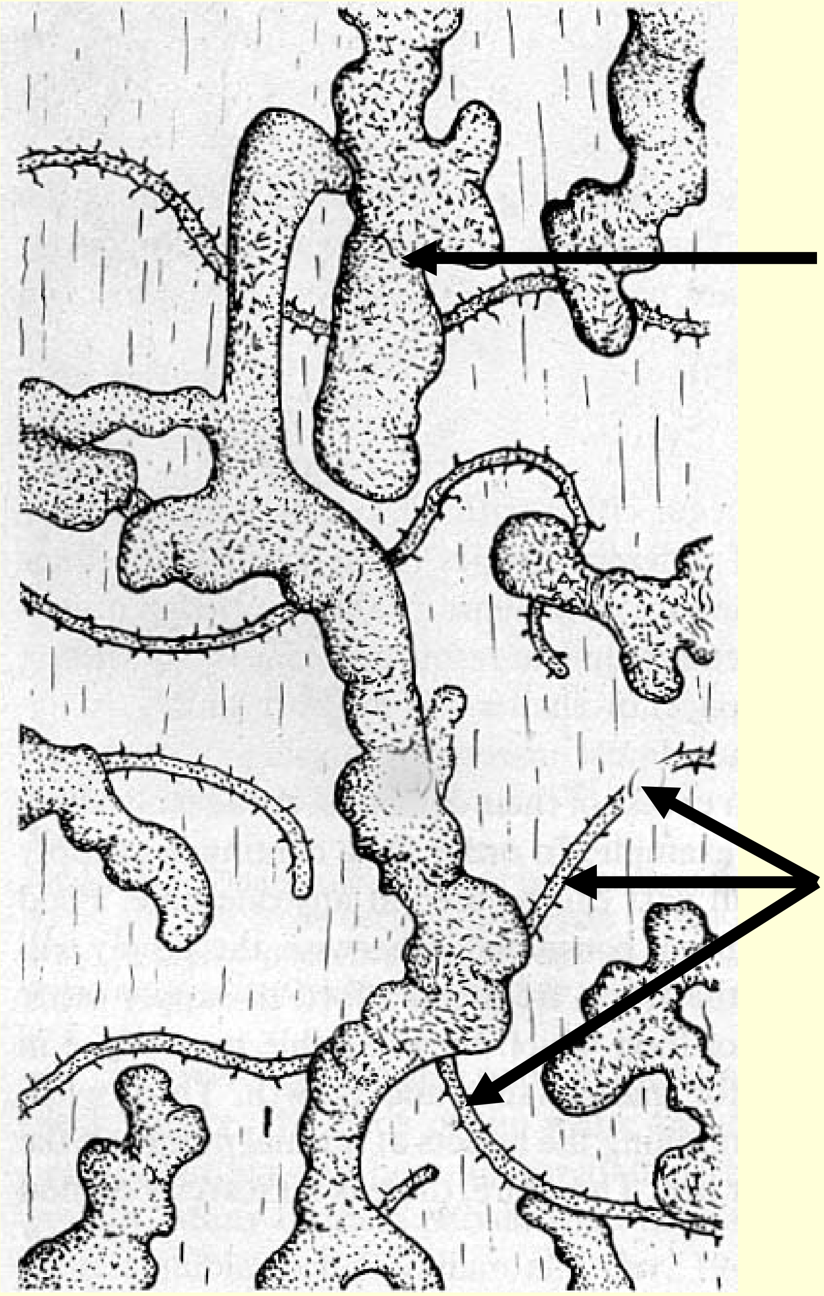


P. strobi distribution and damage



Intraspecific competition of tipweevil larvae as they feed downward in the phloem of their host.





Cerambycid (woodborer) larvae boring through the phloem; just prior to the time they bore into the sapwood.

Egg galleries of the western pinebeetle, *D. brevicomis*, being blotted out by the woodborer feeding galleries.

A couple of principles on competition:

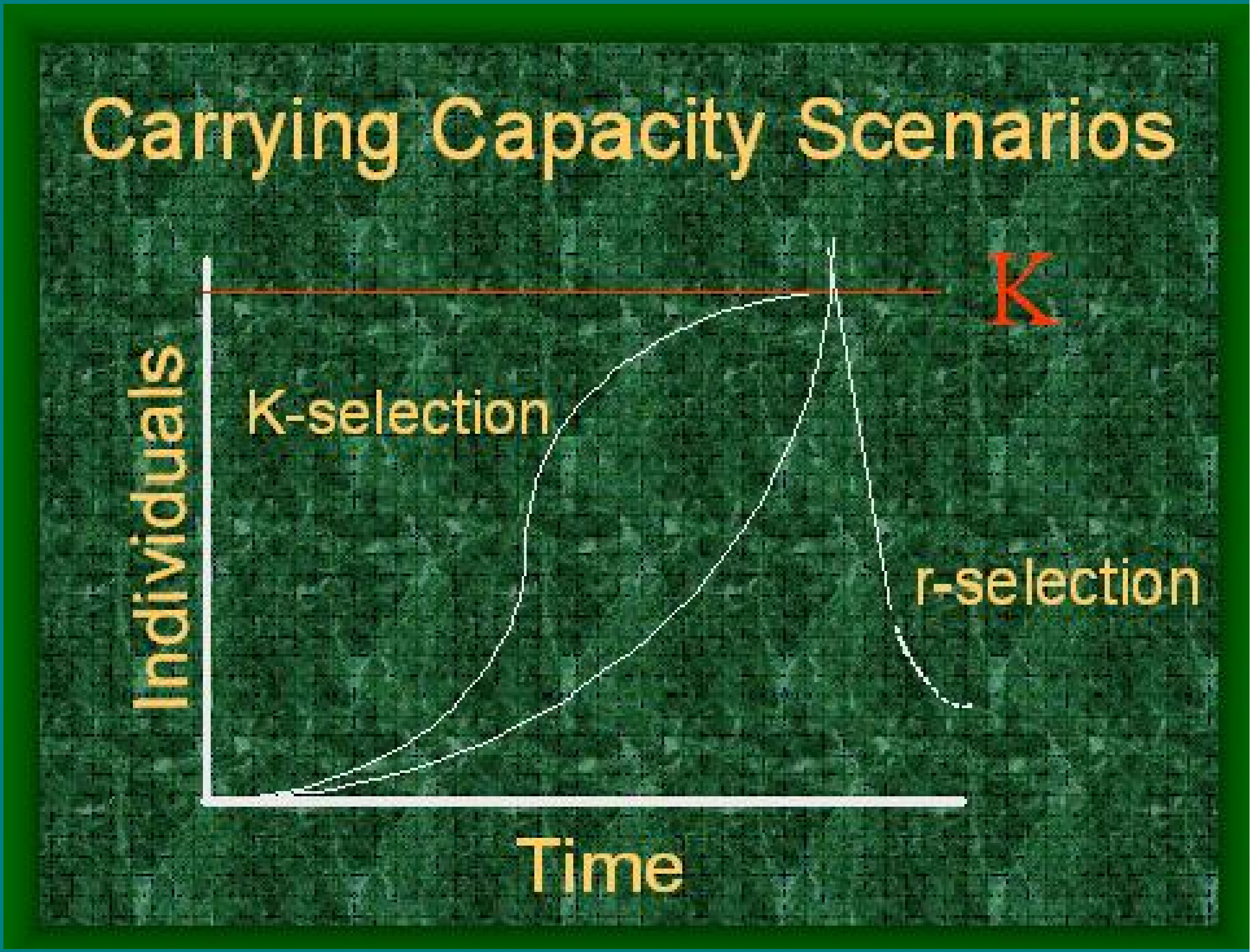
- **If individuals are too numerous, the population will decrease;**

- **If individuals are few, the organisms will increase until their numbers take up all available resources & space. At that instant the population reaches the carrying capacity of the habitat;**

- **Most forest insects have a Rp far in excess of the carrying capacity;**

- **Therefore, competition for space eliminates a large part of competing juveniles.**

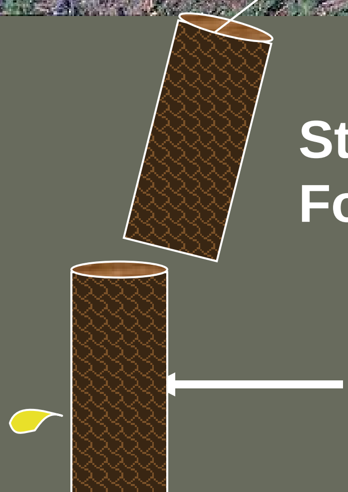
• **k-selection, increases while resources and habitats are abundant. As these factors become limited, birth rate and resources become limited, pop. levels until population reaches steady state.**



• **r-selection, increases rapidly as Rp is enormous and consumes its resource and habitat. Population crashes until resources and habitat recover.**

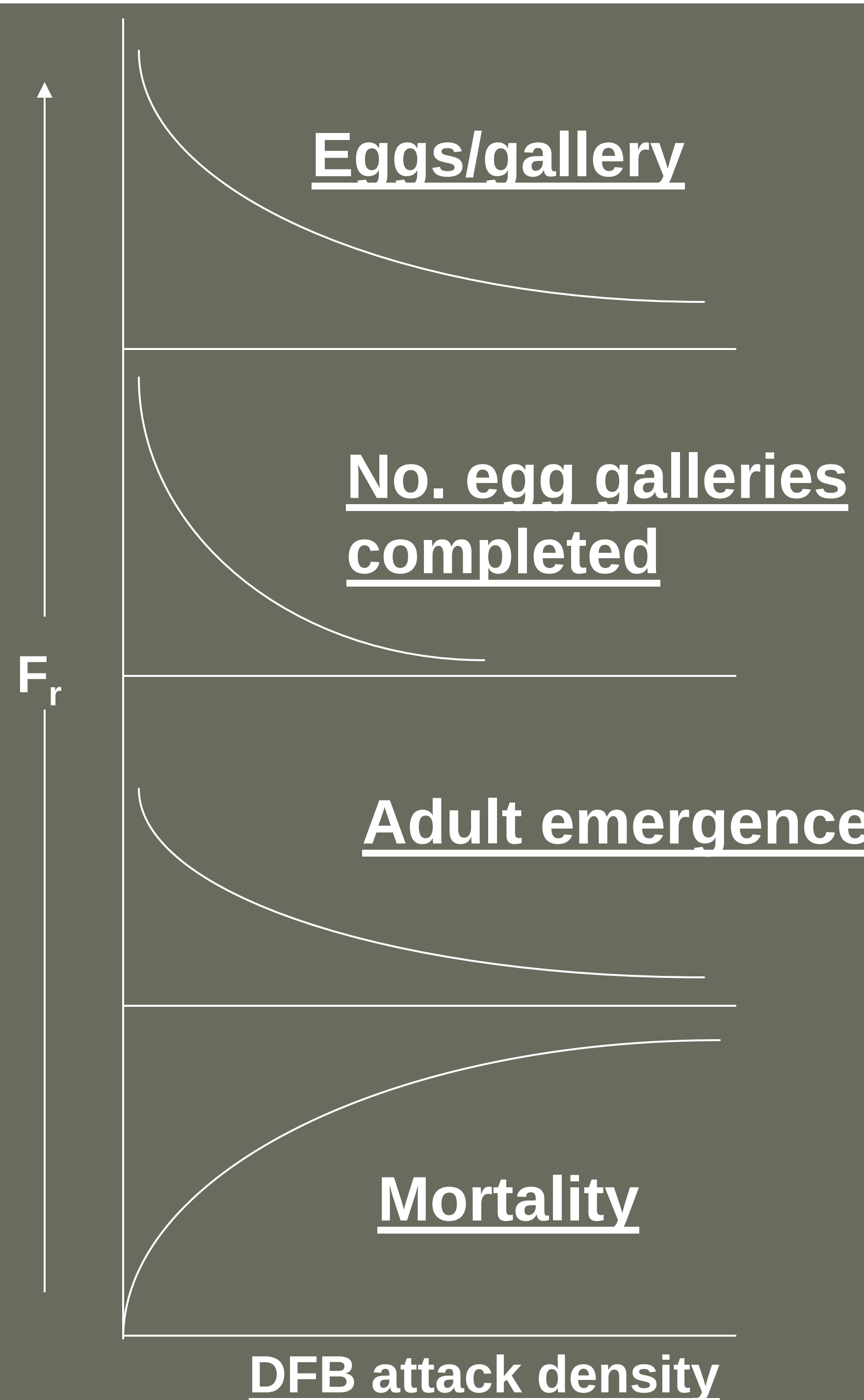
Douglas-fir beetle

Intraspecific Competition



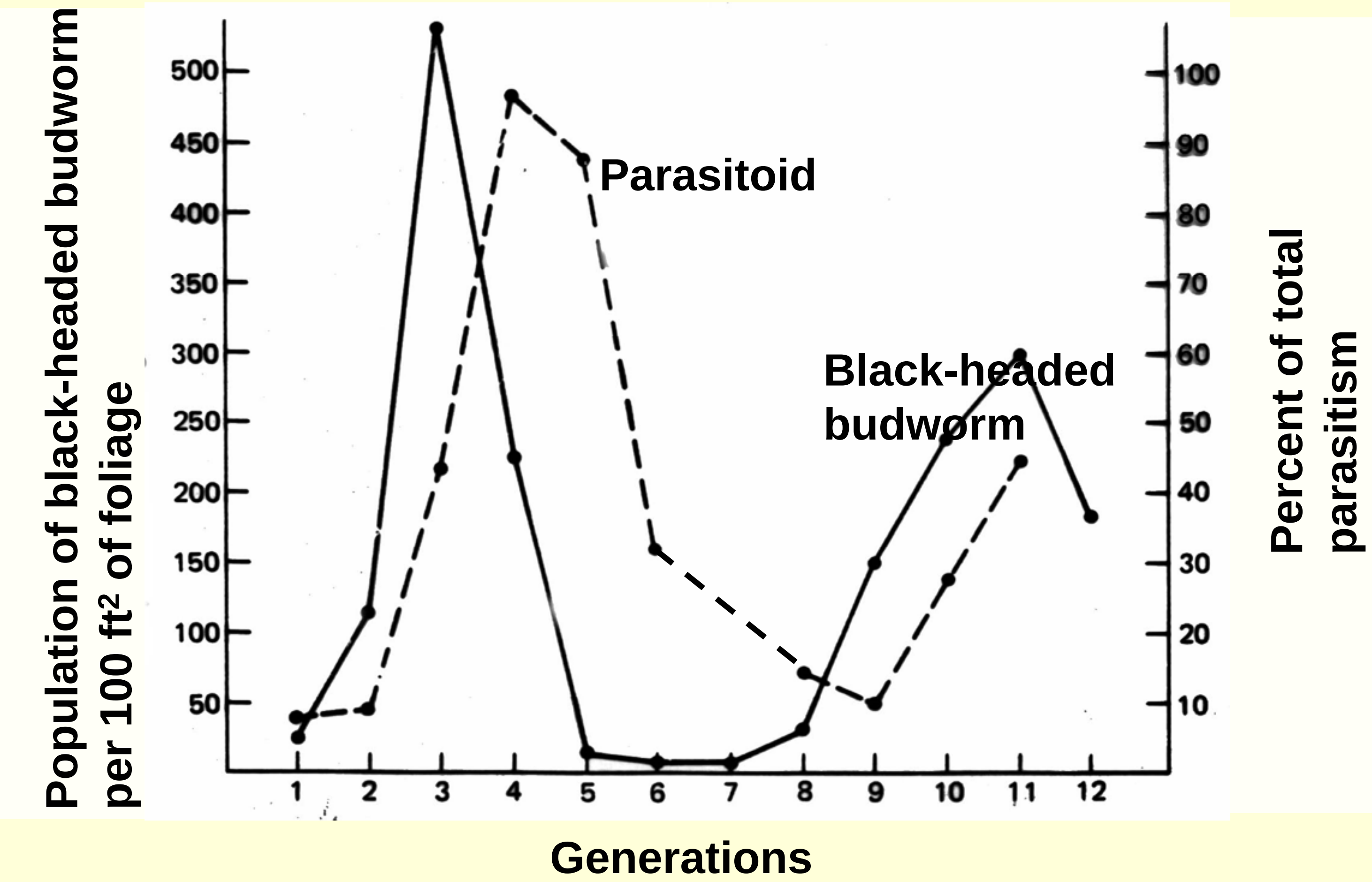
Study by M.D. Atkins
Forestry Canada

Force attack by the DFB at different densities



Interspecific Competition

Examples of Interspecific mortality would be typical parasitoid-host or predator-host interactions. These relationships are "density-dependent relationships."

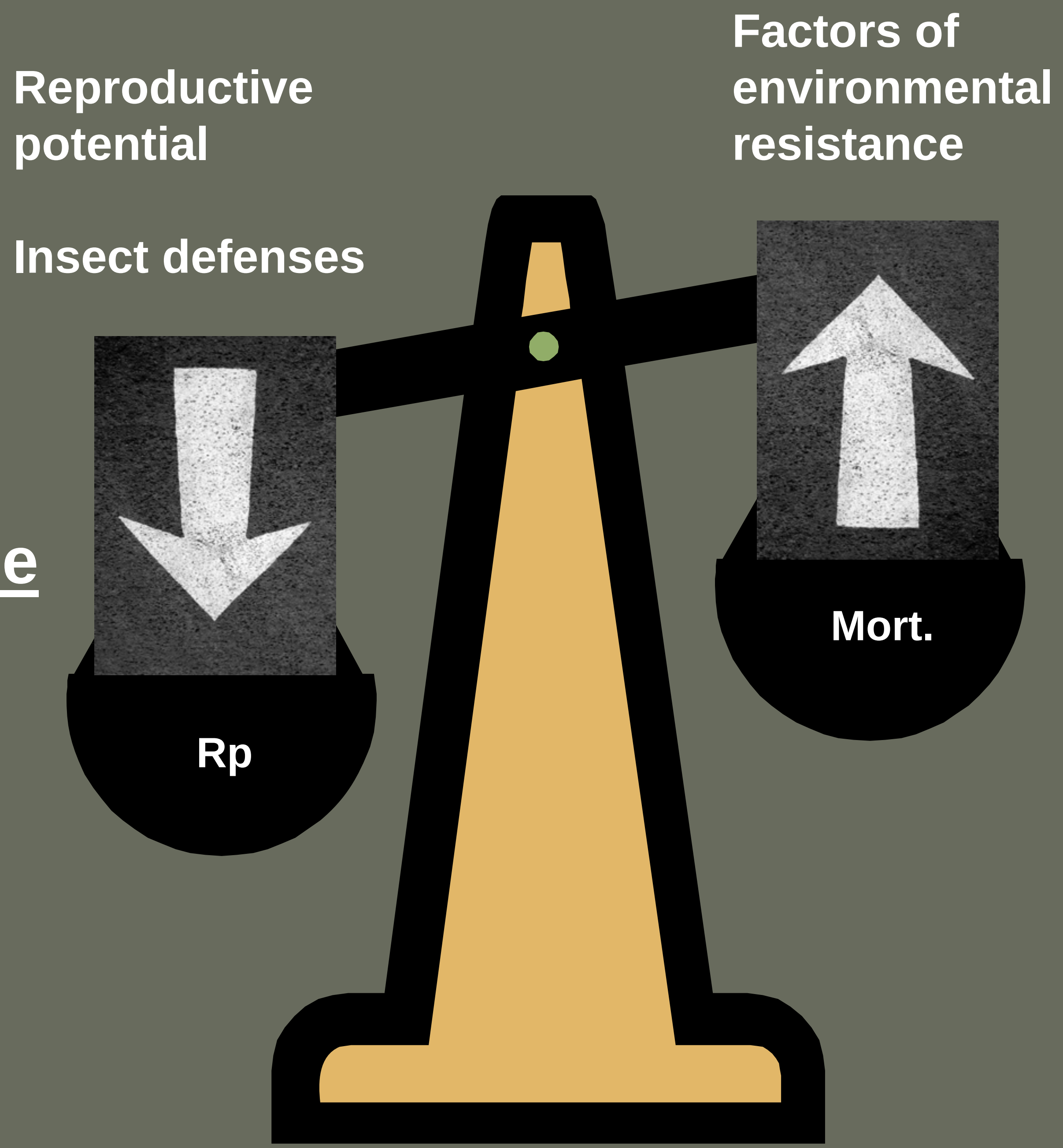


The density-dependent relationship is basic to biological control. Such as introducing parasitoids to regulate pest populations; nevertheless, there are arguments between ecologists: they argue which is most important, Density Dependent or Density Independent mortality in regulating insect populations.

Table 19.2. Difference between density dependent and density independent mortality factors.

	DENSITY DEPENDENT	DENSITY INDEPENDENT
Operation	These factors are always killing the host because their existence is dependent on the host.	These factors kill for short periods and independently of the number of hosts insects present.
Examples	Insect parasitoids, infectious viral, bacterial or fungal diseases, and food quantity	Temperature and moisture extremes, wind storms, heavy rain, and insecticides
Control potential	Given: 50,000 insect pests and there is a 90% control which leaves 5,000 survivors. The population grows to 500,000 but the kill then increases to 99%, leaving 5,000 survivors.	Given: 50,000 insect pests and there is a 90% control which 5,000 survivors. The population grows to 500,000 but the kill remains 90%, leaving 50,000 survivors.

A biotic balance



The conceptual relationships between Factors of Mortality and Insect Defenses

1. When factors of environmental resistance = 0;

2. Rp is realized and a population increases;

3. At this point in time, Insect Defenses = 0 survival value;

4. When environmental resistance is maximum;

5. Insect defenses will have maximum survival value.

So, let’s talk about forest insect defenses and survival strategies. I’ll select a few examples:

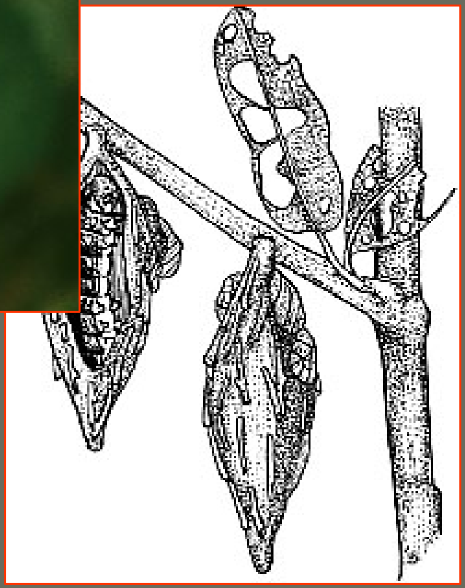
Use of shelter: WSBW

Eggs ov/w in hibernacula that were spun under bark scales ←

Tarpaulin spun in spring as early instars feed on new growth. →

Use of shelter: Larch casebearer

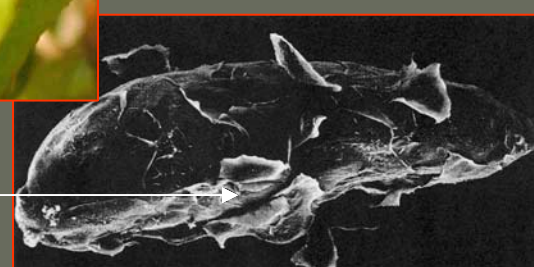
Ultimate shelter: the bagworm



Hemocytic encapsulation, within hemolymph of the larch sawfly, around the egg of a parasitoid wasp, *Mesoleius tenthridinis*: a defense mechanism against biological control.

Larch sawfly, *Pristiphora erichsonii*

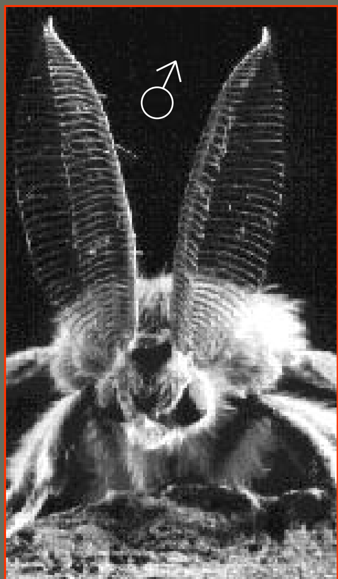
Parasitoid, *M. tenthridinis*



Flattened hemocysts

Encapsulated egg of *M. tenthridinis*.

Pheromones have great survival value: sex pheromones, aggregants, and trail pheromones.



Male moth responding to sex attractant

Aggregant of codling moth; attracts ♂ ♀

Ant trail pheromone

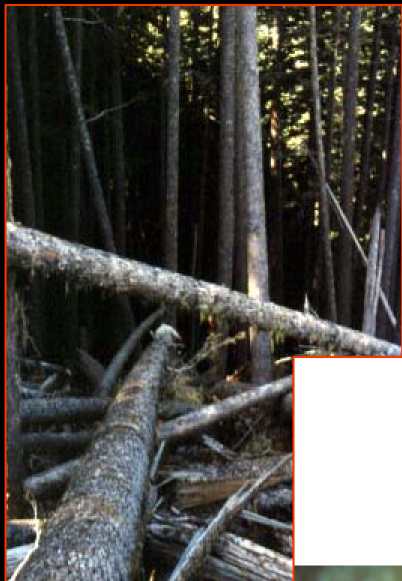
Host selection strategies have great survival value, and are of special interest to me. I'll give two examples: the mahogany shoot borer and the bark beetles.

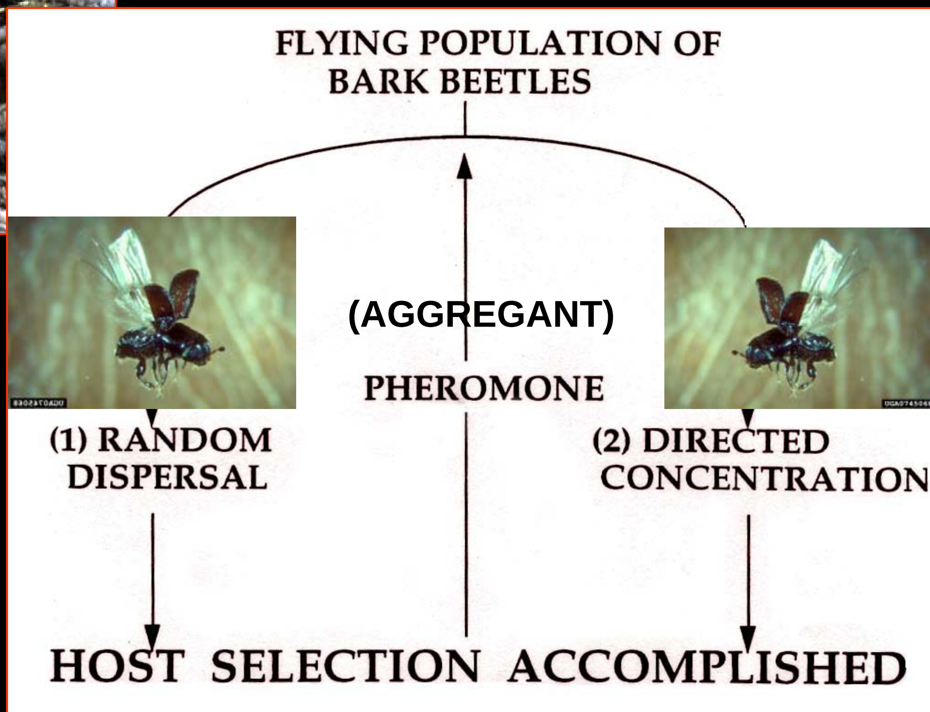
Do you see any barkbeetles yet?

Barkbeetles live in still-fresh-phloem of logs, blowdowns, dying trees, freshly fire killed trees etc. THIS IS A TEMPORARY HABITAT. Remember?

In other words, barkbeetles have a finely tuned host selection plan to find their perishing and scattered habitat.

Host Selection Behavior of Barkbeetles





Another fantastic host selection strategy belongs to the mahogany shoot borer, *Hypsipila grandella.*

<u>Some history:</u>

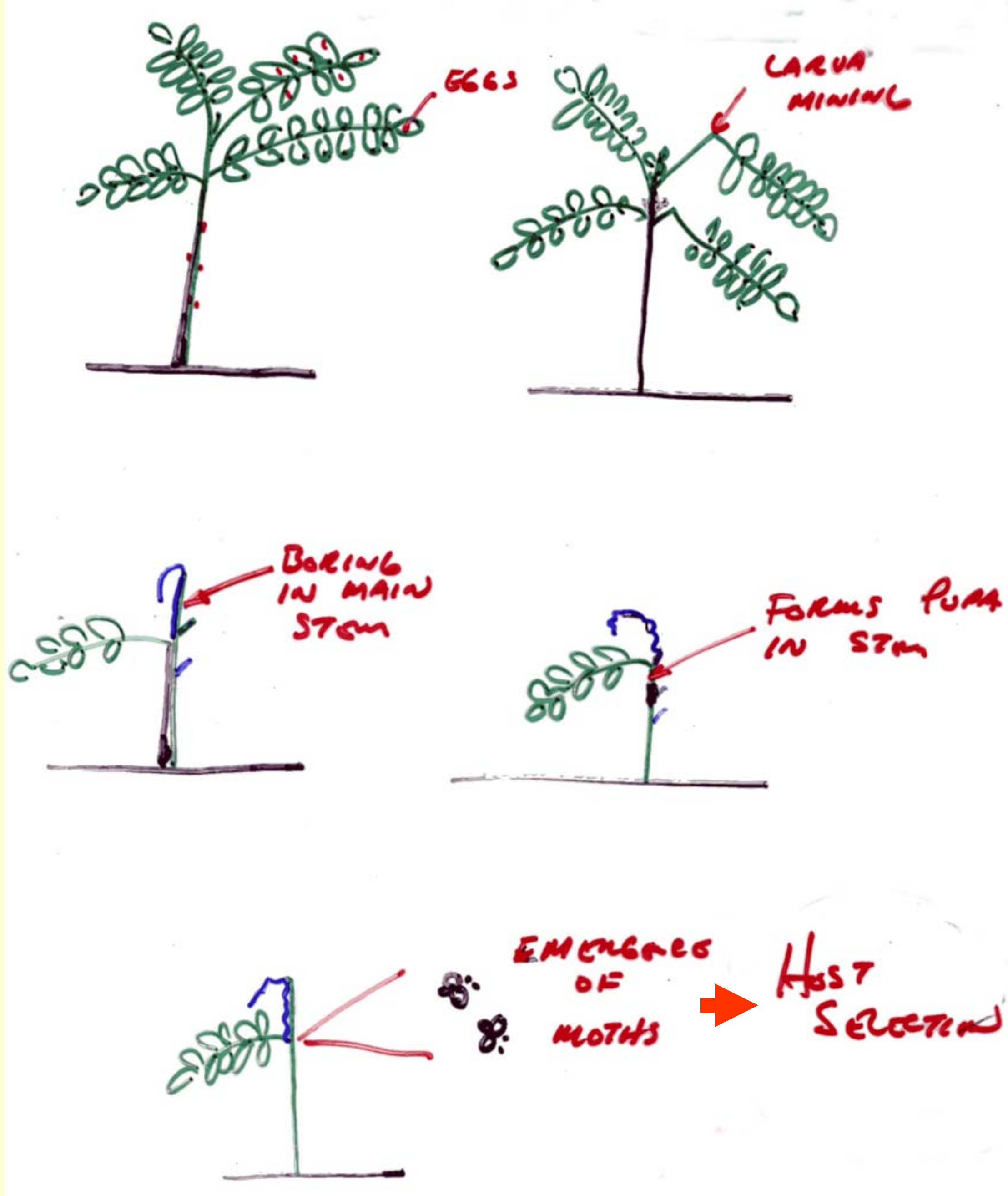
- **Many yrs ago I went to Turrialba, Costa Rica to study the biology and control of the mahogany shoot borer;**

- ***H. grandella* attacks the upper stem of young members of the Meliaceae, *i.e.* mahogany, Spanish cedar, caoba, *Toona,* other valuable tropical Meliaceae.**

- **Since pan-tropical Meliaceae are so terribly valuable, why not grow them in plantations?**

- **It's being tried, but attempts to grow the Meliaceae fail as they are simply feeding grounds for mahogany shoot moths!**

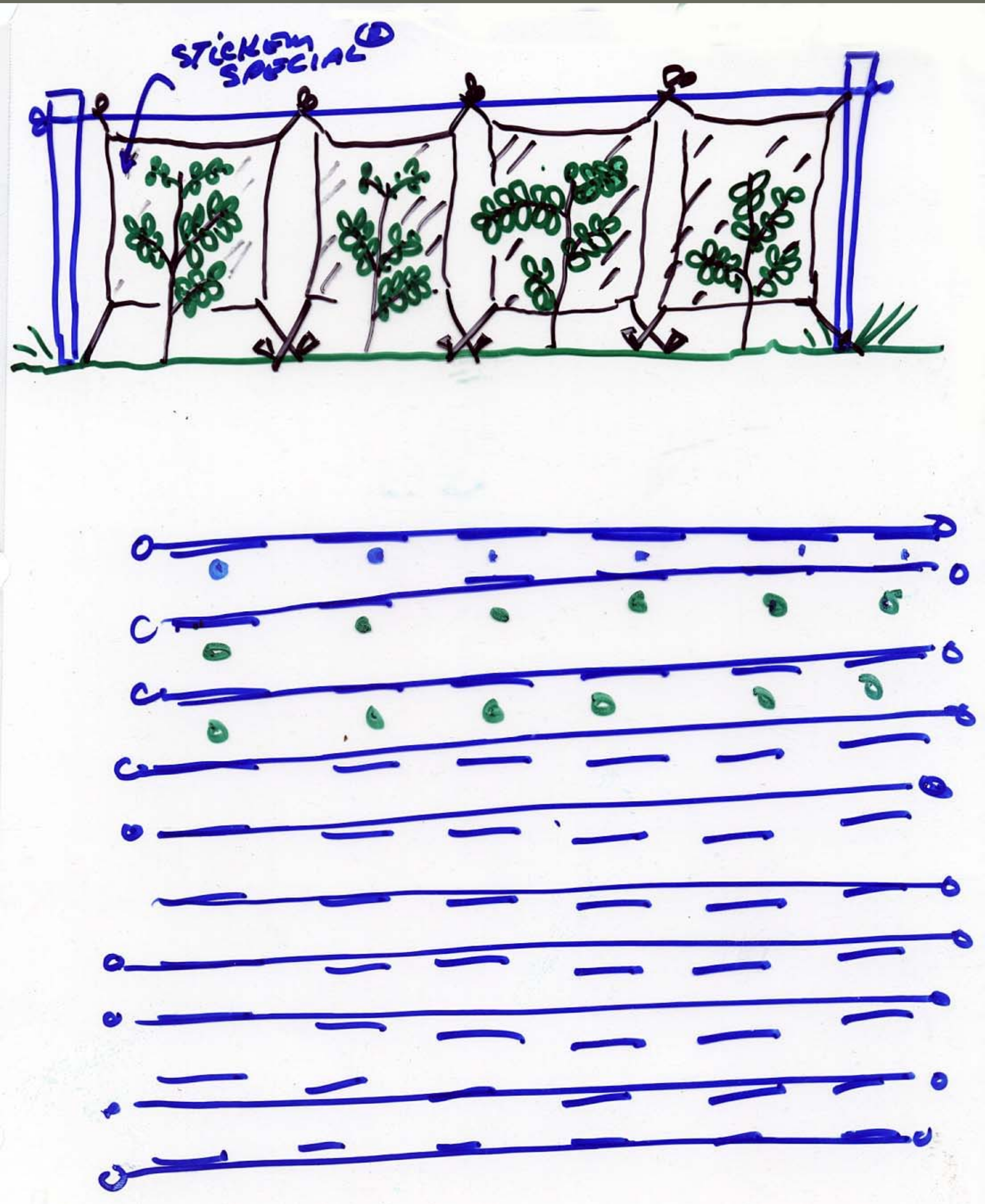
Life cycle of the mahogany shoot borer on Spanish cedar, *Cedrela odorata.*



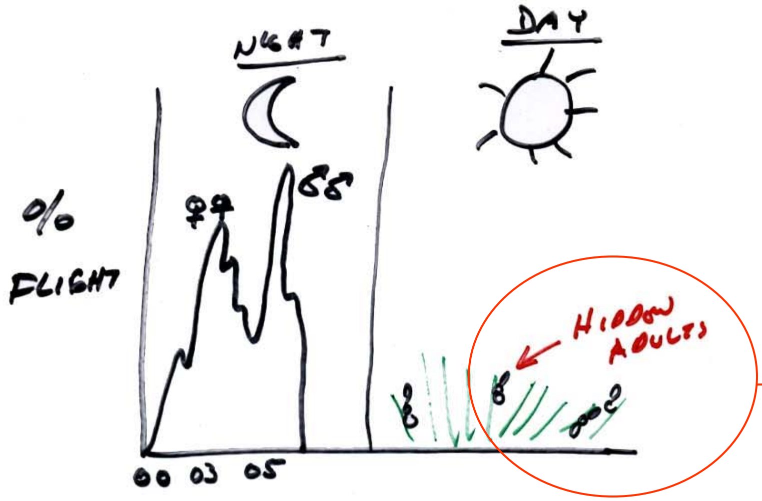
Life history of the mahogany shoot borer at the Meliaceae plantations of CATIE in Turrialba.

Barrier traps determine when, where and at what height the moths fly.

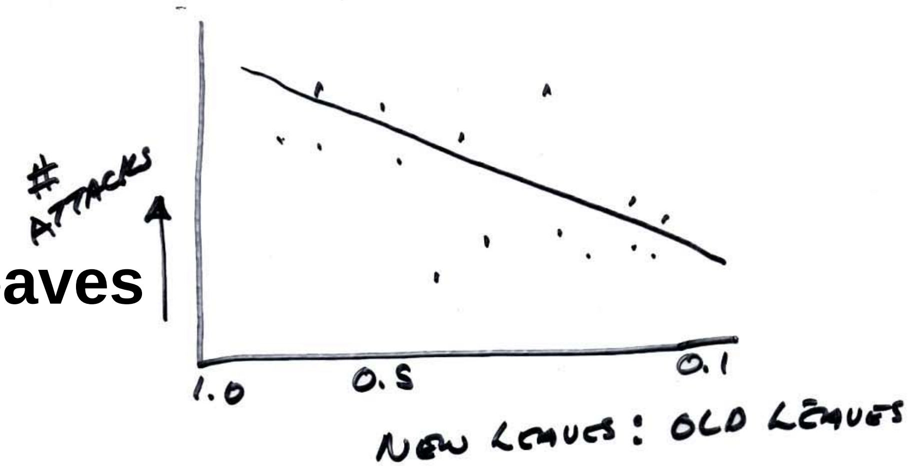
Trapping studies to learn more about flight and attack patterns of *H. grandella*.



1. Daily flight



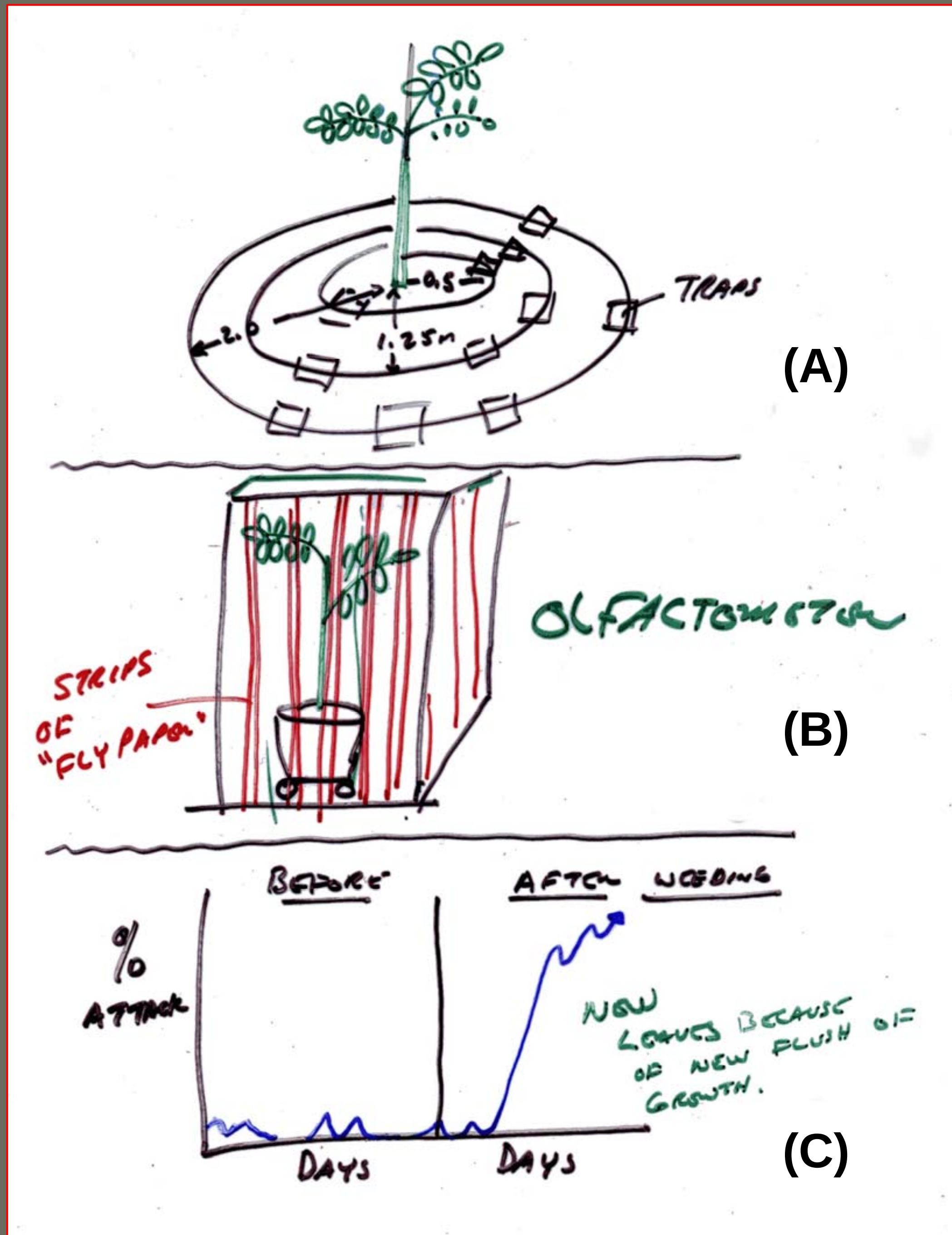
2. New leaves versus old leaves



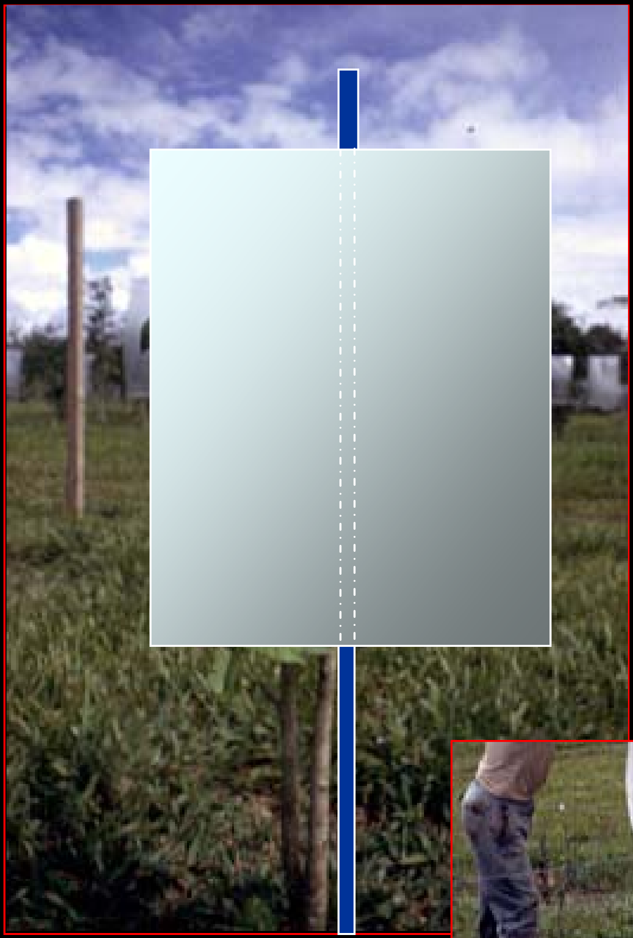
Repeatedly attacked *C. odorata;* after the tree is attacked new leaves sprout again.

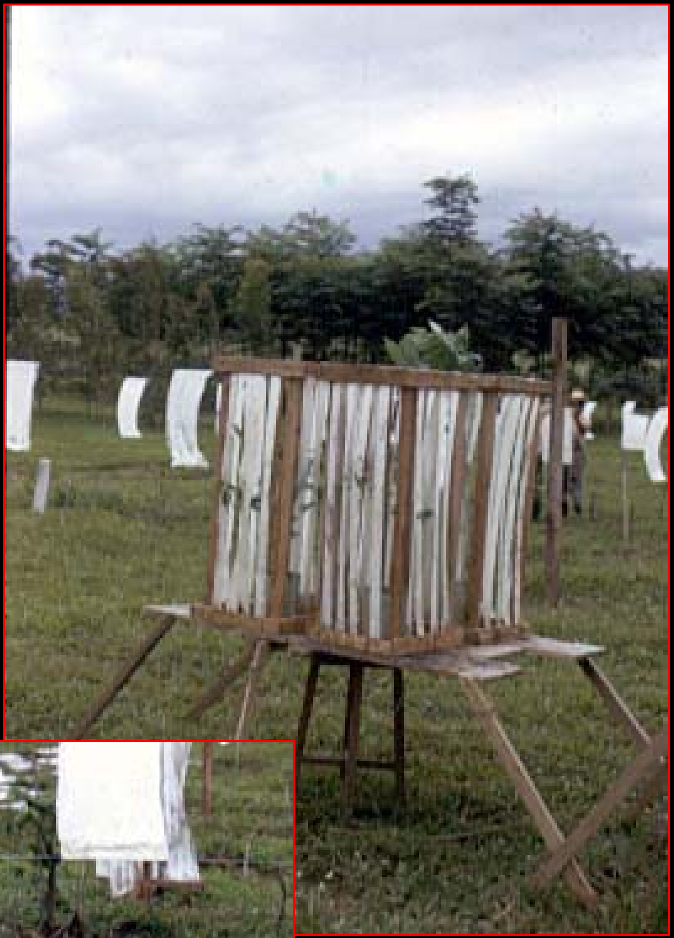
Since new leaves apparently attract new attacks by *H. grandella*, we came out with the working hypothesis that new foliage contains volatile chemicals that attract female shoot moths.

<u>Studies:</u> Concentric traps around tree (A); olfactometer with trees that had new leaves and/or mature leaves (B); a *C. odorata* plantation that was covered with vines and the trees were slowly dying. Then the vines were cleared and new leaves sprouted (C).



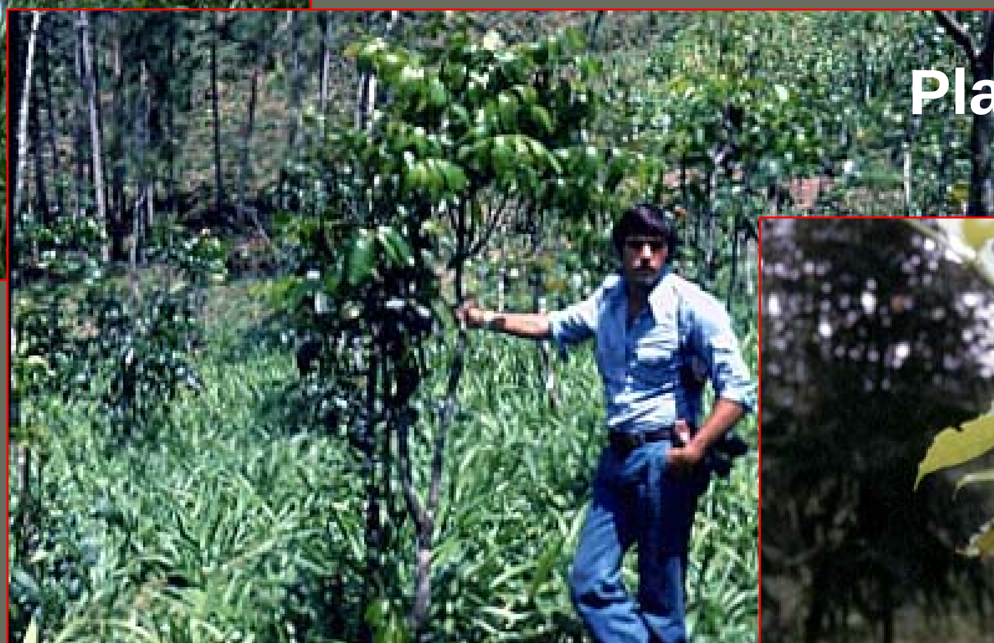
Trapping





Plantation being strangled by high grass and vines

Plantation cleared

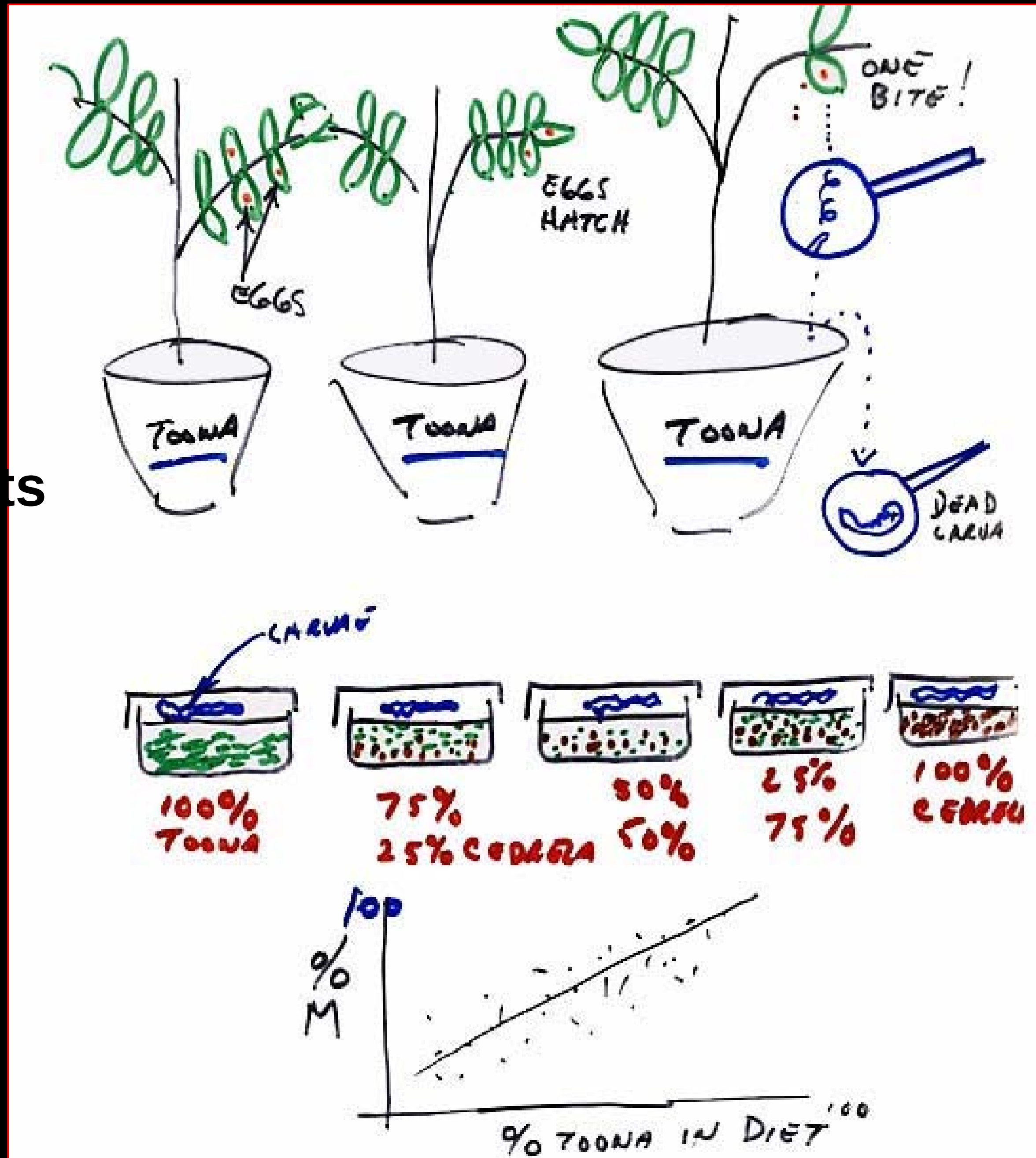


Re-attack

File all this information away. An Asian Meliaceae, *Toona ciliata,* is not attacked by the new world shoot borer, *H. grandella.*

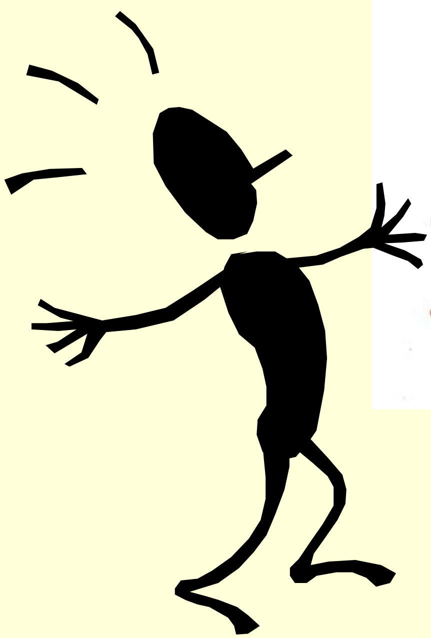
A plantation of *T. ciliata* at Turrialba, Costa Rica. ⟶

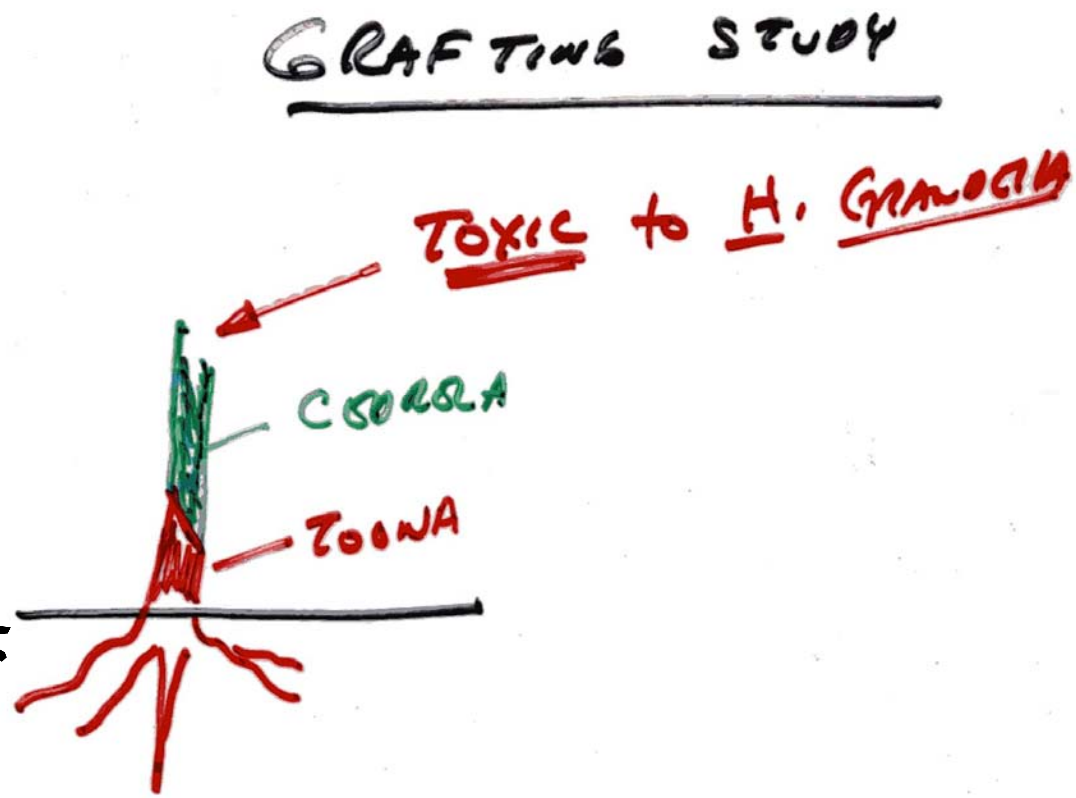
Toona Experiments



Photos by our student in Bulolo, New Guinea: toona before attack (A); after it's attacked by *H. robusta* (B) and the *H. robusta* last instar in stem of T. ciliata (C).

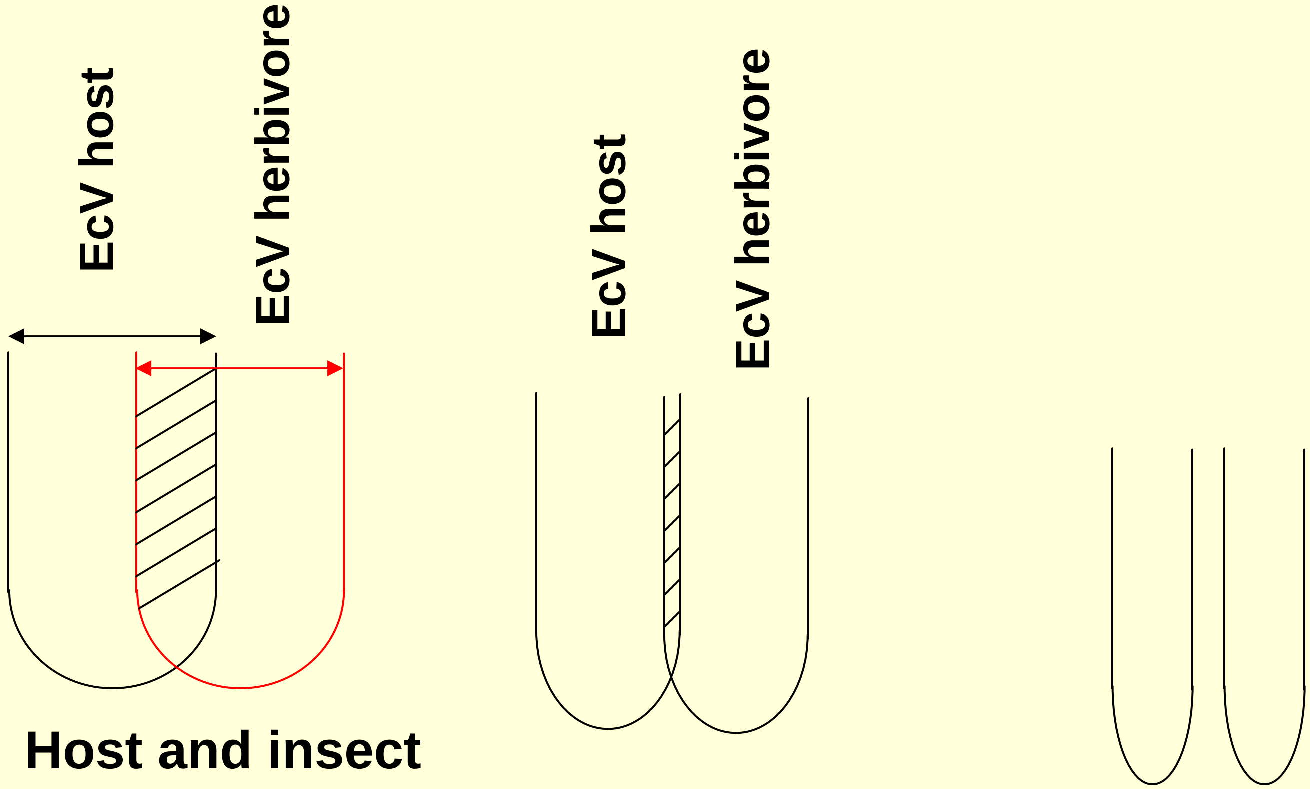
When scions of cedrela were grafted unto toona root stock, *H. grandella* eggs placed on the cedrela foliage never produced larvae that survived!





EcV = ecological valence

(valence = "relative ability of things to react or interact")

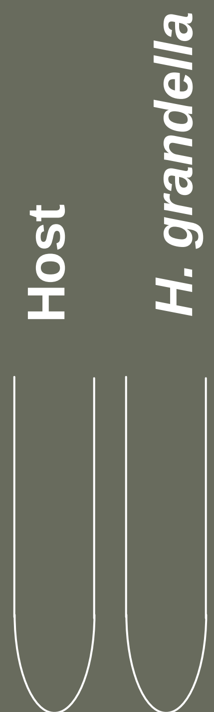


Host and insect EcV overlap

Host and insect EcV still overlap

No longer a fit

A Case of “one up-man ship.”



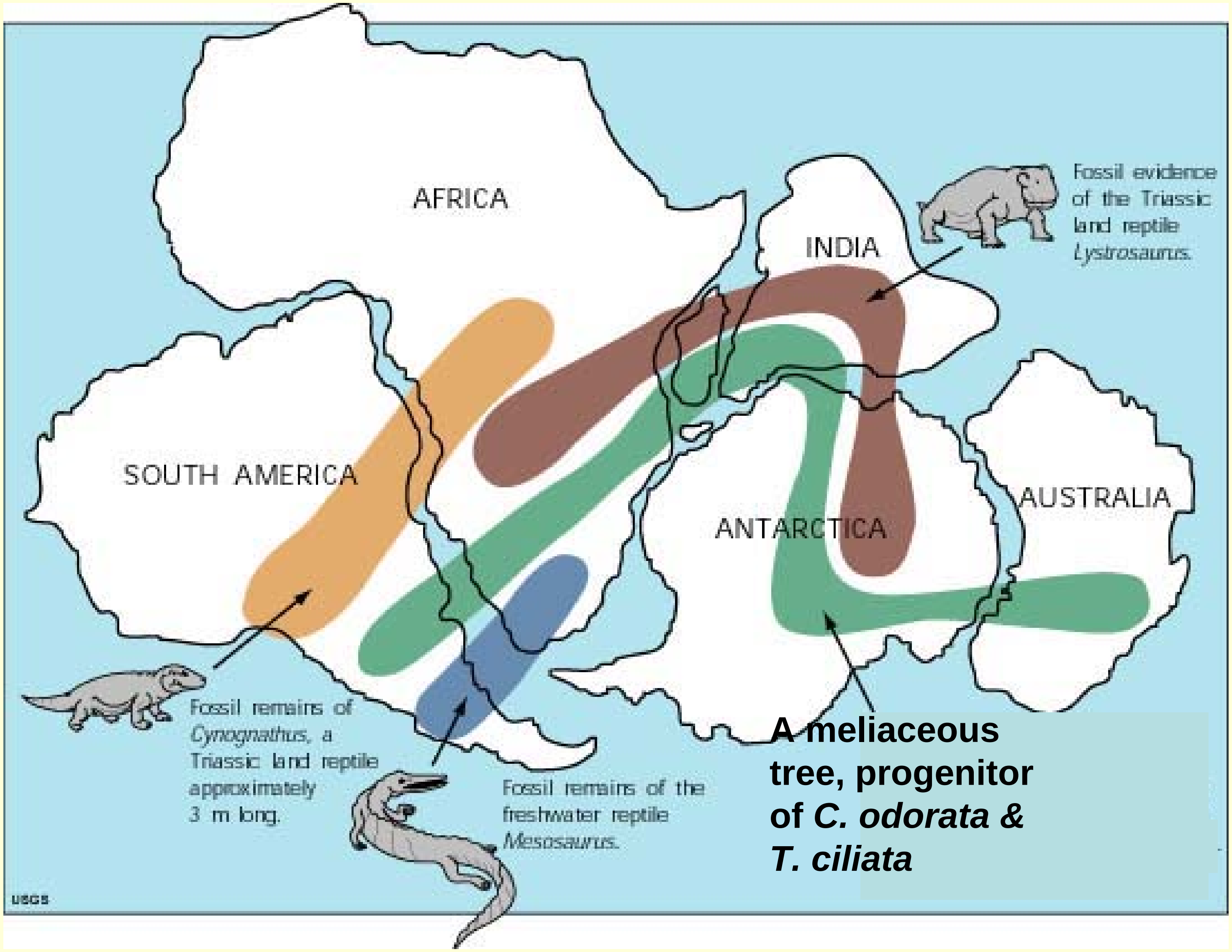
No longer
a fit

- This “breaking of the fit between the host and the shoot moth” never happened, because of *H. grandella’s* evolution of an incredible host selection behavior.

- *H. grandella* uses the toxic compound that *C. odorata* evolved as a **host selection** cue -- kairomone.

- It is a means for finding scattered and rare hosts in the native rain forests.

Pangea 230 million yrs ago



- **About 250 million yrs ago as Pangea drifted apart, a meliaceous host and their *Hypsipila* spp. shoot borers were isolated.**

- **In the new world arose *C. odorata* and its herbivore, *H. grandella*; in Asia and Africa arose *Toona ciliata* and its herbivore, *H. robusta*.**

- **Similarly *C. odorata* developed its foliar toxic compound (an allomone) which, in time, *H. grandella* used as a 1^0 host-finding cue (kairomone).**

- **In the Asian-African Region, *T. ciliata* developed its allomone, but *H. robusta* now uses it as a kairomone.**

(1) <u>We know this speculation is right:</u>

• The toxic volatile in toona is still toxic to *H. grandella*, and

• The toxic volatile in Spanish Cedar is toxic to *H. robusta*.

(2) <u>If we could isolate</u>, identify and synthesize the toxicant in *T. ciliata* we would have a:

- species specific insecticide
- non-toxic to other insects
- the insecticide would be systemic

We struck out.

Conclusion:

The host selection mechanism for the shoot borers that attack the Meliaceae is a most effective survival strategy.