# Forest Insect Ecology

# But first: the insectan mode of life.

(1) Saprophagous -- Feed on dead organic matter.

- General scavengers
- Humus feeders
- Dung feeders
- Dead plant tissues (woodborers, ambrosia beetles etc)
- Carrion feeders

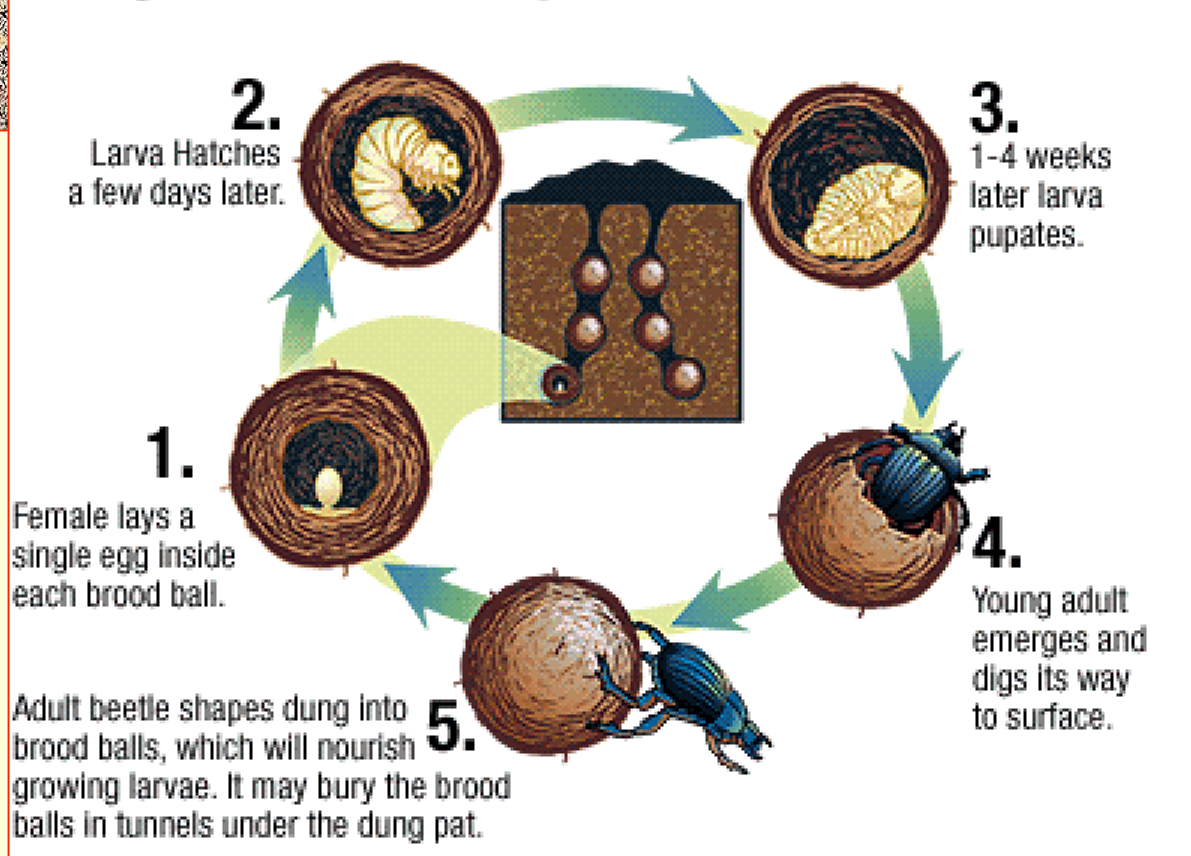
(2) Phytophagous -- Feed on living plant matter.

- Leaf chewers (defoliators)
- Leaf miners (defoliators)
- Stem girdlers (barkbeetles)
- Stem borers
- Gall makers
- Sap suckers

(3) Zoophagous -- Feeding in or on living animals

- Parasitoids
- Parasites
- Predators

# Dung Beetle Life Cycle



The carrion feeding beetles, Trogidae, and Dr. Chuck Baker.
Classes: I, II, III, and IV

## Remember: Insect parasitoids always kill their prey.

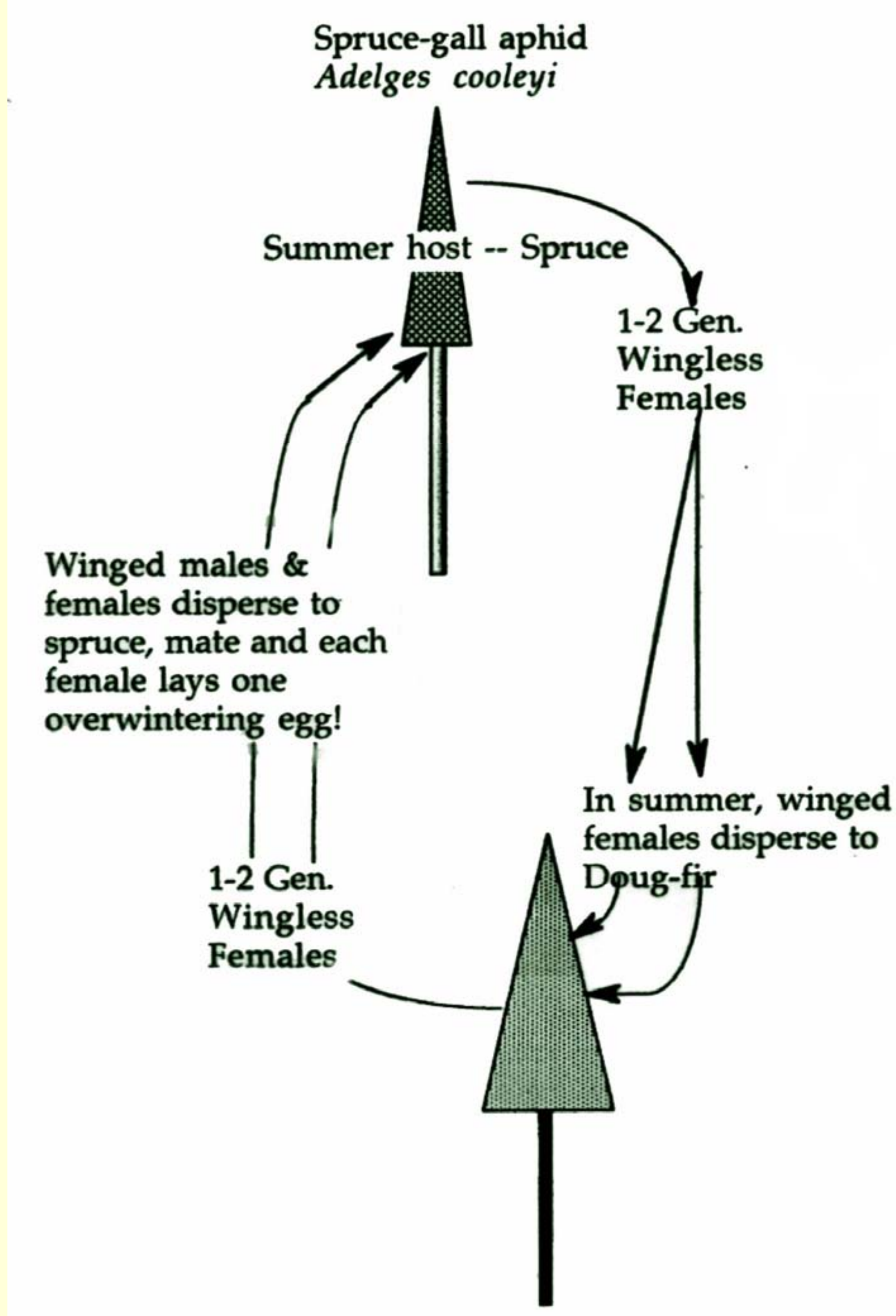
**It's not that entomologists who established the word "parasitoid" were from Brooklyn…**

**Toity poiple boids a-sittin' on de koib a-choiping and a-boiping and eating doity woims and their parasitoids.**

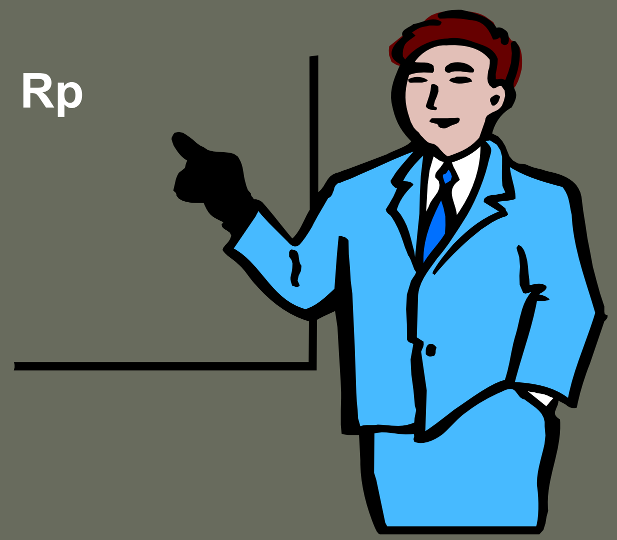
# A bit about reproduction in insects

Reproduction can be:

- Oviparous
- Viviparous
- Viviparous
- By paedogenisis
- By parthenogenisis
  - sporadic
  - constant
  - cyclic



## What factors determine how fast insect populations reproduce or the Reproduction Potential?



# 2 factors used in calculation of Rp: Fecundity & SR

Table 4-1 Fecundity of Some Major Forest-insect Pests, Determined by Various Means

| Species | Eggs | Authority |
|---|---|---|
| Spruce budworm (eastern) | 359 | Morris, 1963 |
| Gypsy moth | 1178 | Brown and Cameron, 1979 |
| Forest tent caterpillar | 327 | Hodson, 1941 |
| Saratoga spittlebug | 15 | Ewan, 1961 |
| Balsam woolly adelgid | 248 | [illegible] |
| White pine weevil | 115 | |
| Pales weevil | 107 | |
| Southern pine beetle | 159 | |
| Engelmann spruce beetle | 176 | |

(1)

**SexRatio:** (no. females/population)

*e.g.* --

- collect 1000 pupae of WSBW
- raise them to adults
- 500 are females
- $SR = \frac{500}{1000} = 0.5$

(2)

As long as an insect population can breed without biological or abiotical restrictions, the reproductive potential is: $Rp = Z^n$

**REPRODUCTIVE POTENTIAL OF INSECTS: RULE OF**

Reproductive Potential: $Rp = Z^n$

Where: Rp is Reproductive Potential
$Z$ = (Fecundity)(Sex Ratio)
$n$ = Number Generations per Yr.

Fecundity = The average number of eggs laid/female.

$$\text{Sex Ratio} = \frac{\text{No. Females}}{\text{No. of Individuals in the sample}}$$

## An example:

Western spruce budworm (WSBW)

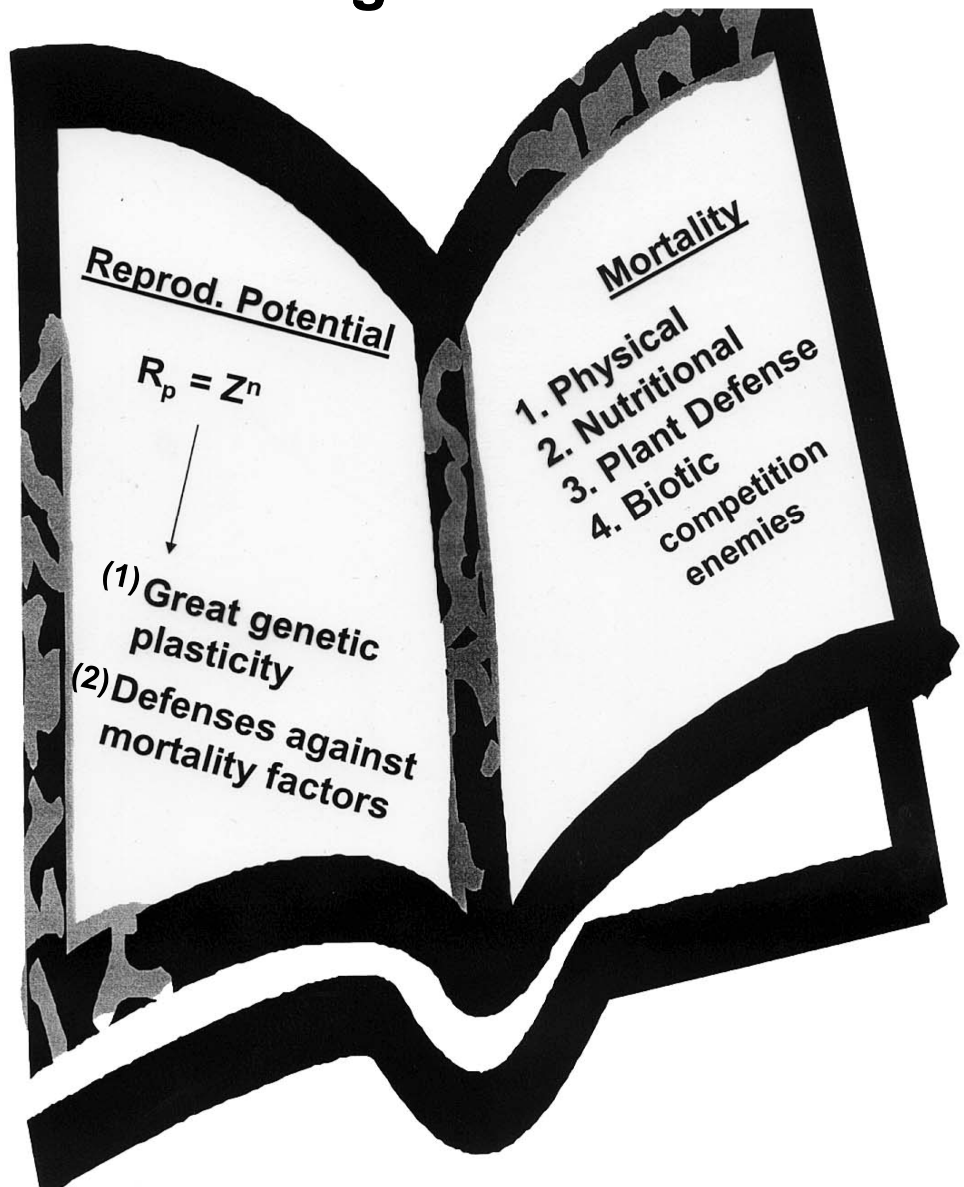
- Fecundity = 175eggs/female
- SR = 0.5
- One generation/yr

$Rp = [(175)(0.5)]^1$

So, 1 female can produce 87.5 new individuals

What about the great ledger of life?

# What insects have going for them & against them



## Mortality factors work against the Rp:

1. Physical: weather, moisture, light

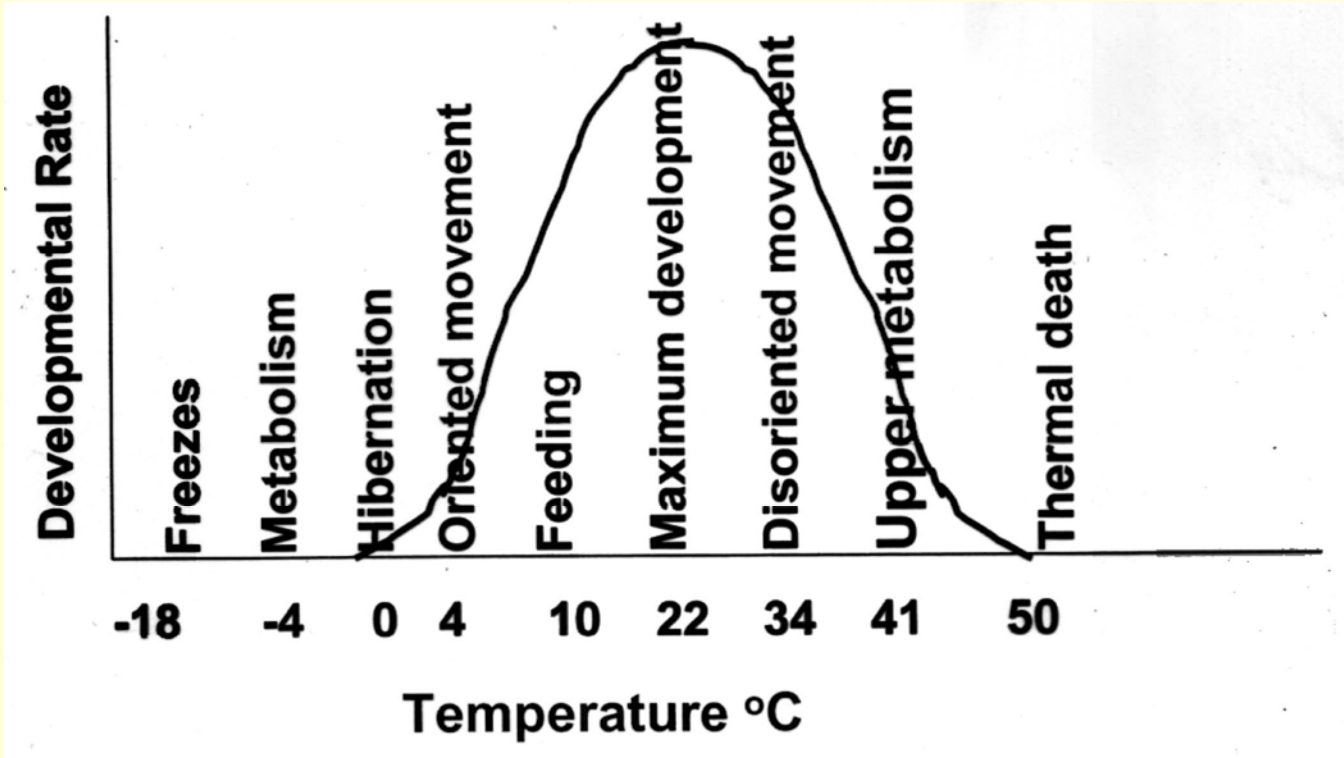
2. Nutritional: qualitative and quantitative

3. Biotic: natural regulation by living factors

# Physical mortality-factor: temperature

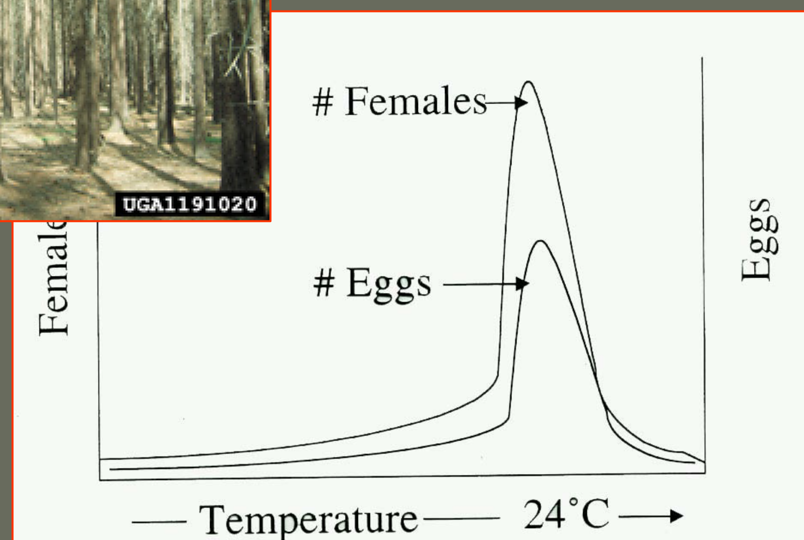
**Most important factor in regulating insect numbers, but each species has a definite temperature range within in which it lives or dies.**

**Douglas fir beetle: *Dendroctonus pseudotsugae***

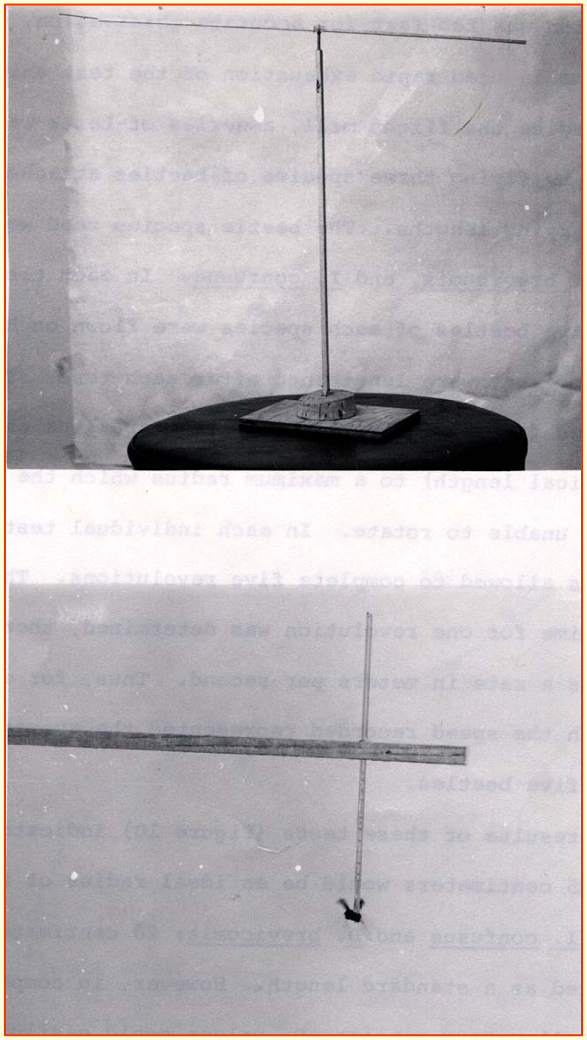


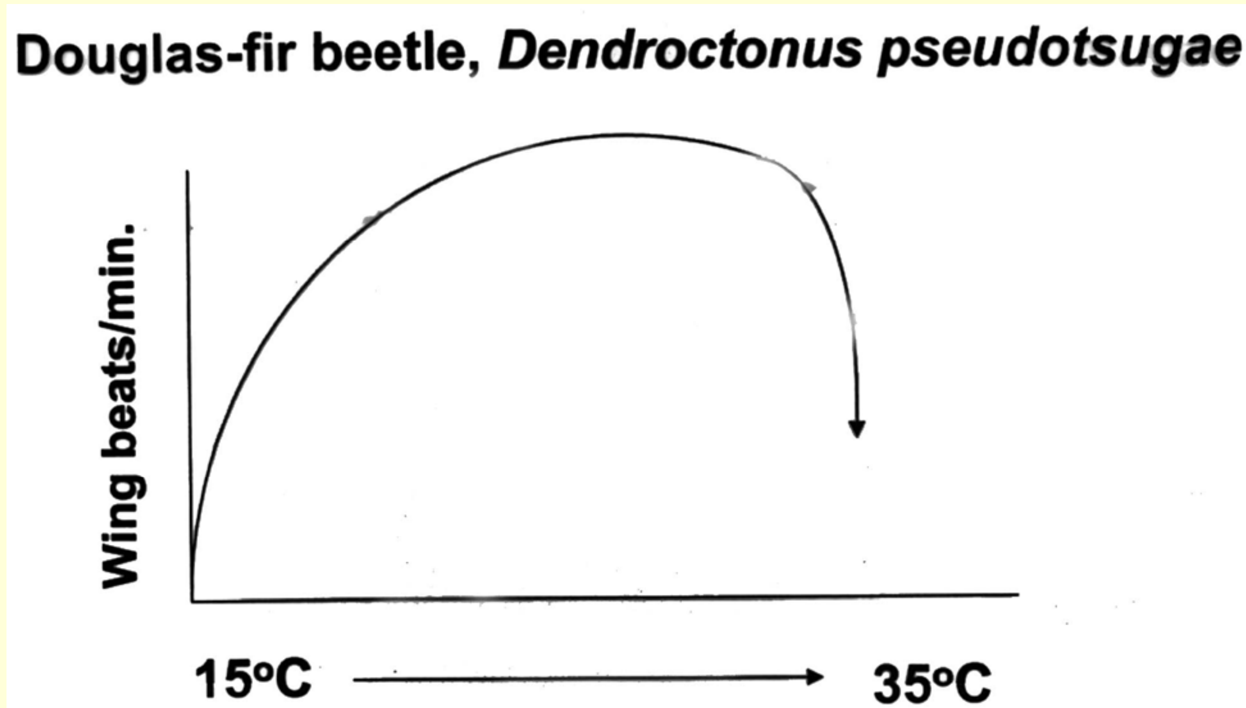
## A European Example

It's not clear why, but at an optimal temperature more female nun moths, *Lymantria monacha,* are produced

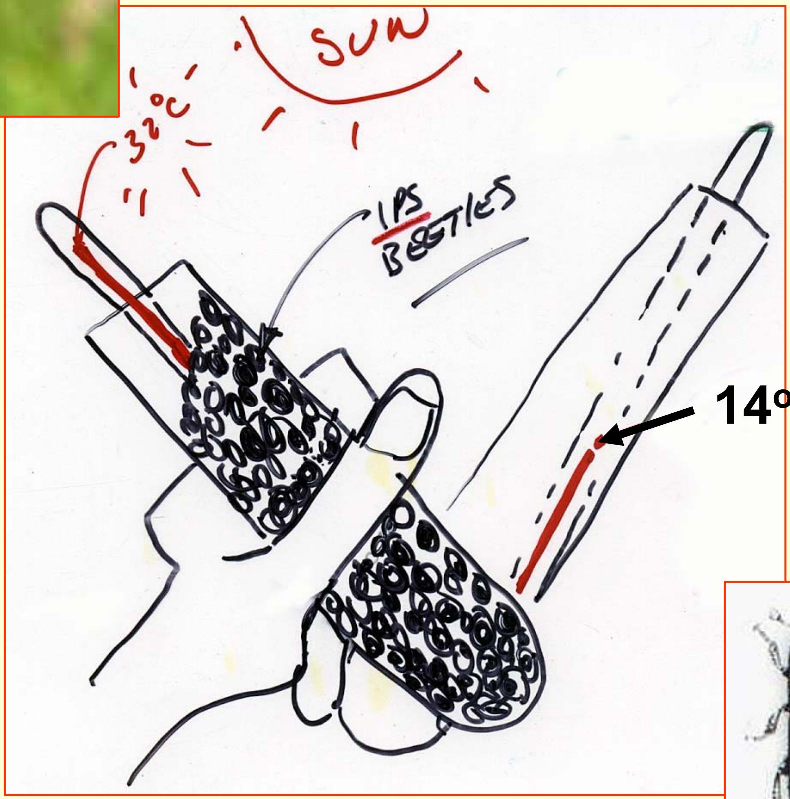
# Wingbeat frequency of the DFB





**As insects have certain temperature ranges for flight, look for sun-basking**

- **cerambycids**
- **bumblebees**
- **flies etc.**



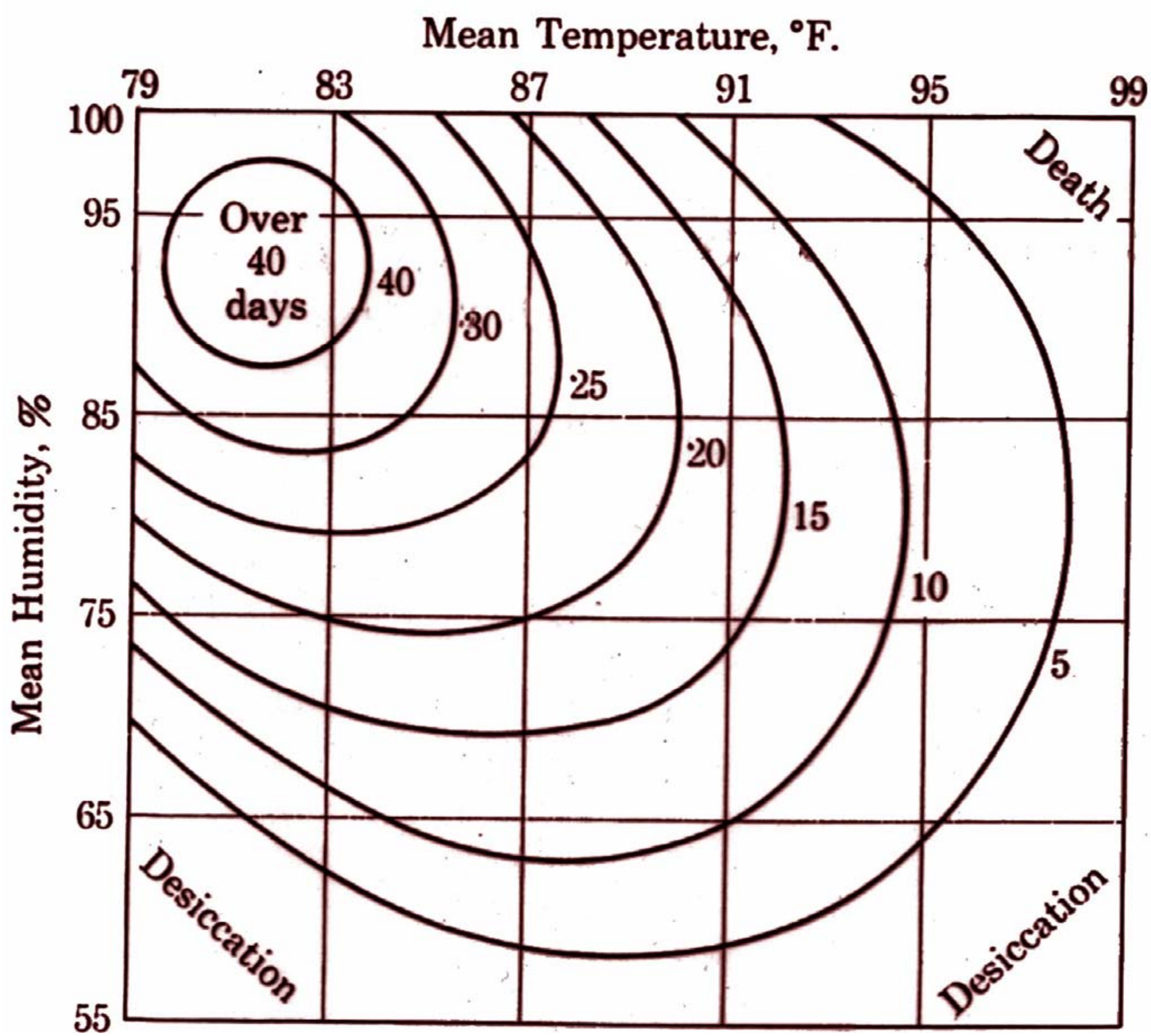

# Mortality-factor: moisture

- Under favorable moisture conditions, forest insects are less susceptible to temperature extremes.

- Forest insects have definite combinations of temperature and humidity regimes that are either lethal or beneficial.

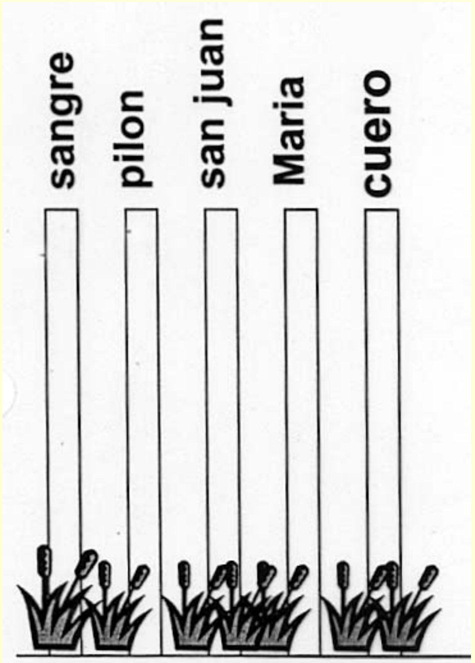
# Habitat Parameters

**Zones of maximum life of an adult cerambycid, *Hoplocerambyx spinicornis,* at different combinations of temperature and relative humidity.**

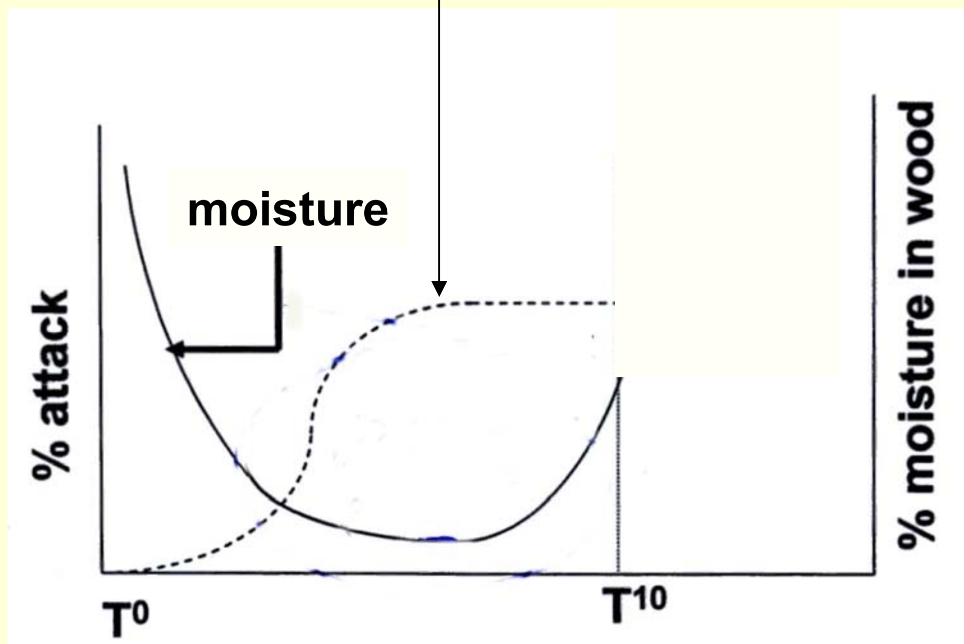


# <u>Studies with *Xyleborus ferrugineus* and moisture</u>

Posts of: "sangre, pilon, San Juan, Maria and cuero de sapo."




*Xyleborus*
**attack**
**leveled off**



**Attacks leveled off as the host material became drier?**

**Why?**

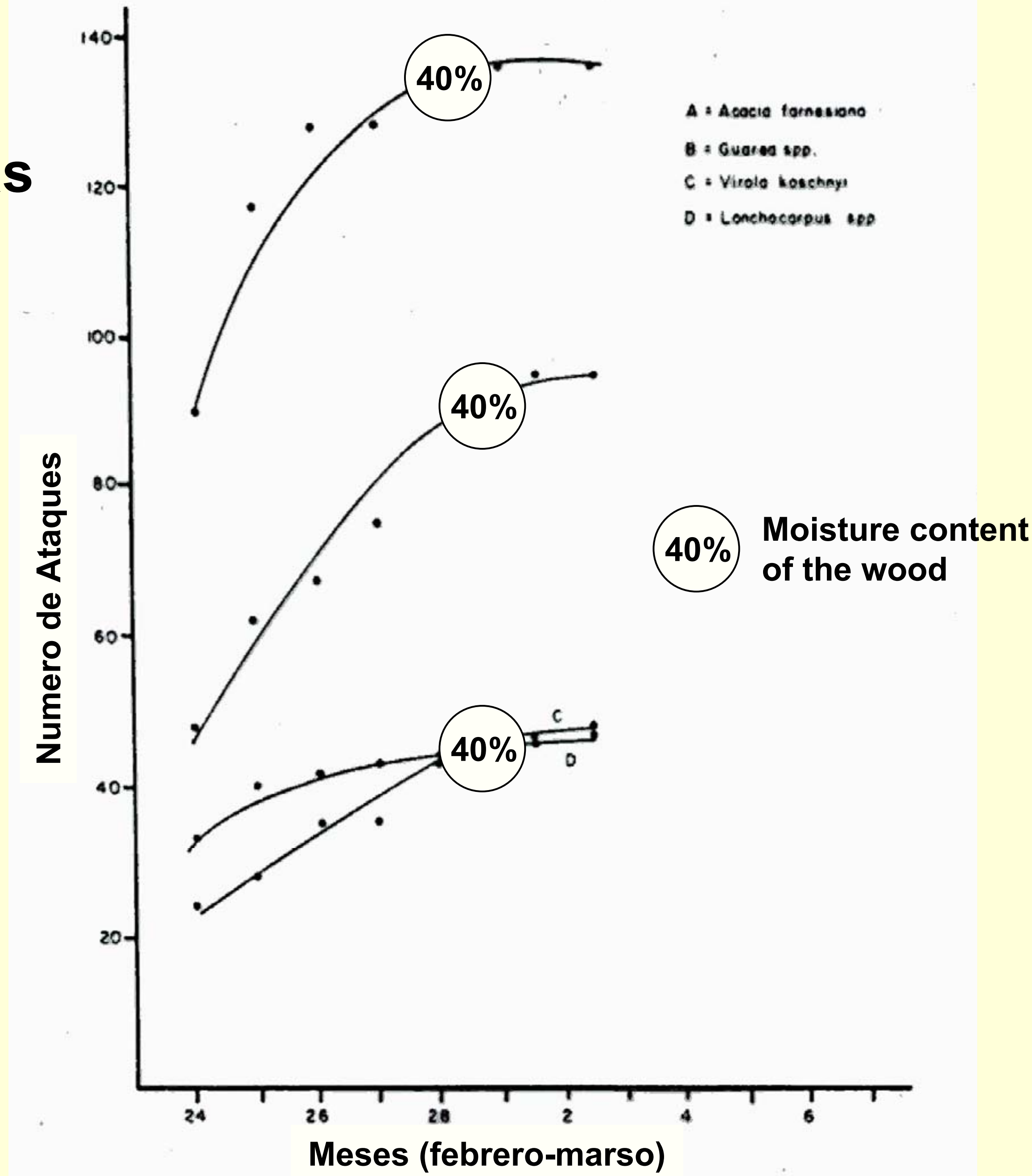
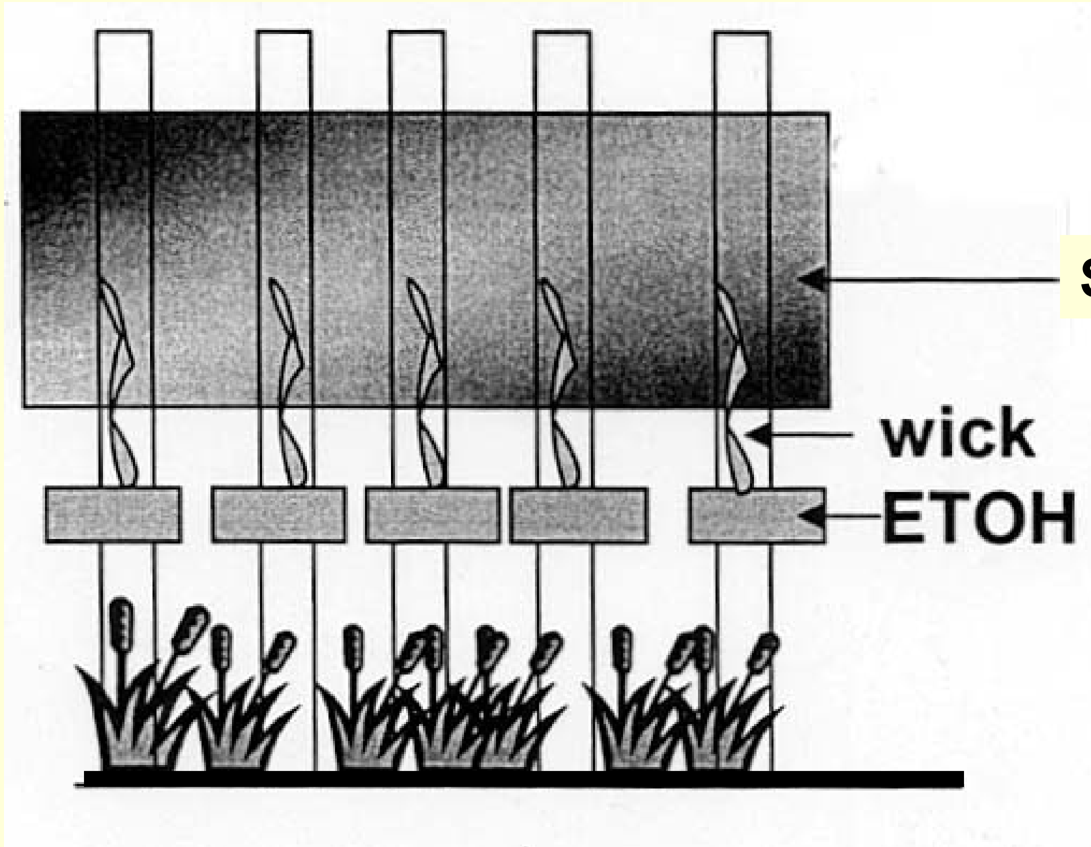



Fig. 6.—*Número de ataques realizados por los escolítidos ambrosía a cuatro especies de madera.*



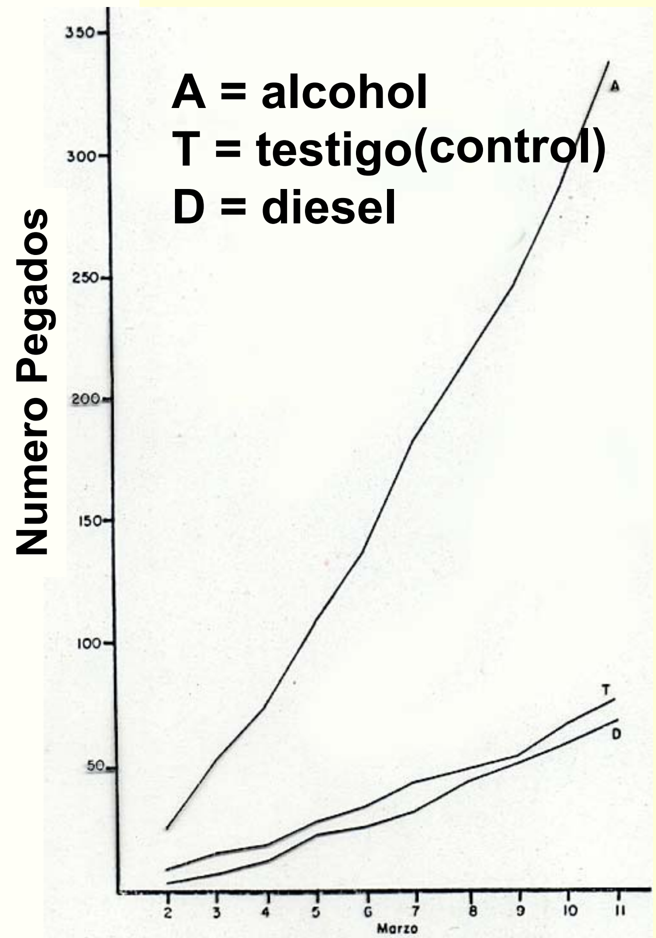
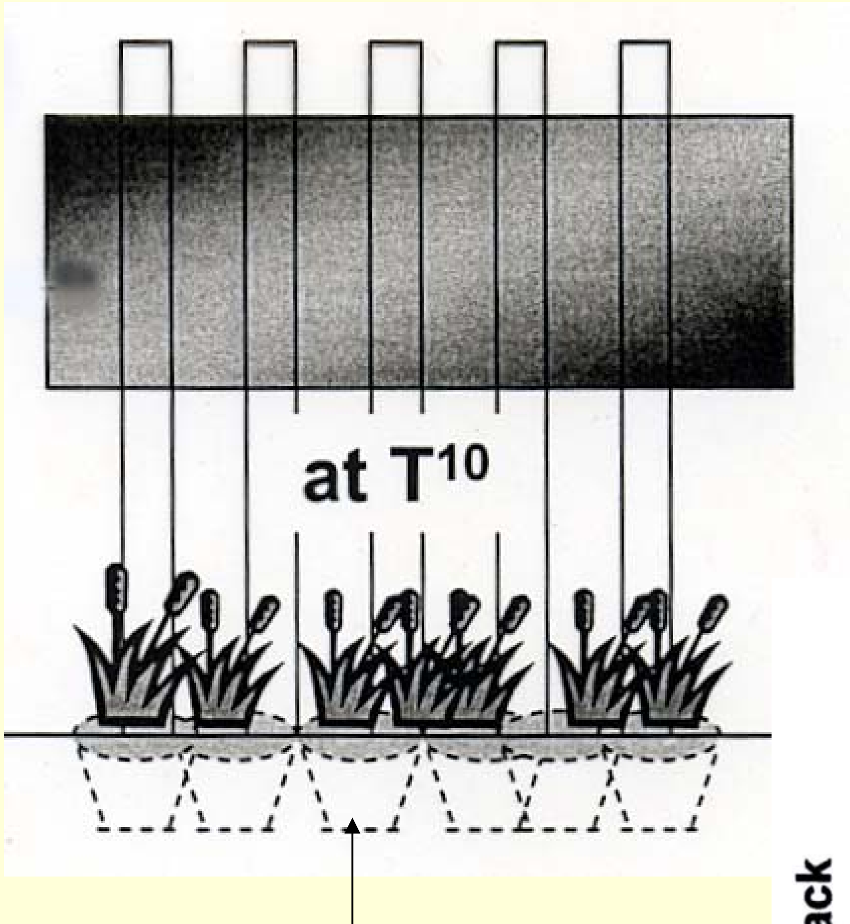



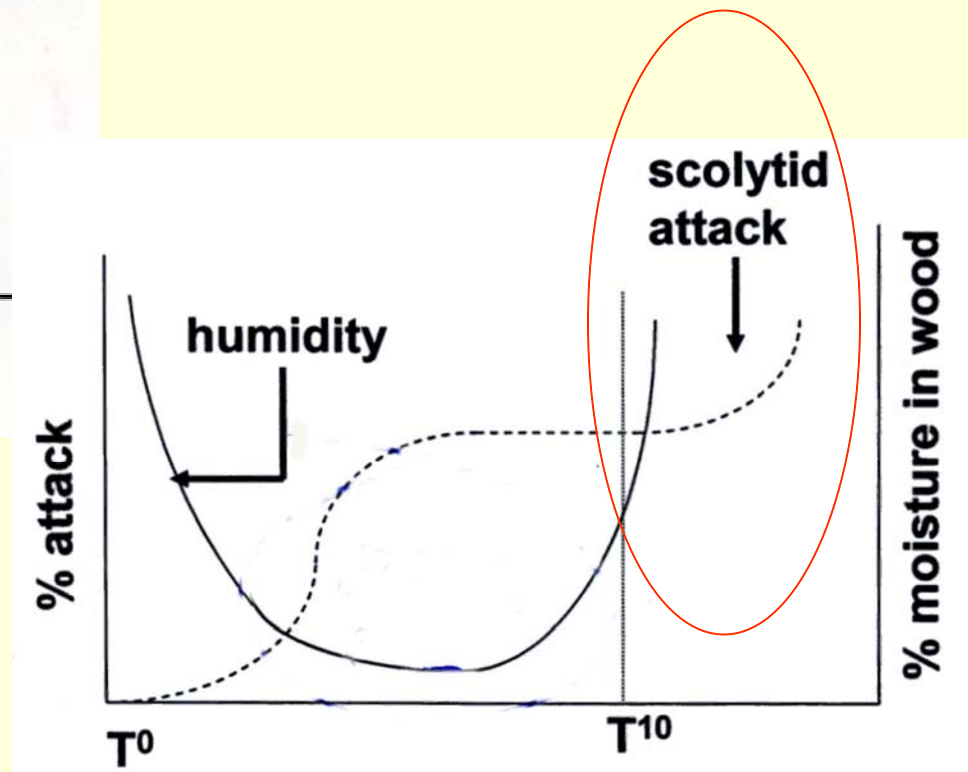

Fig. 7.—*Respuesta de los Escolitidos a los atrayentes primarios*

**Ok, ambrosia beetles were attracted but no new attacks.**




Plastic wash basins with water.

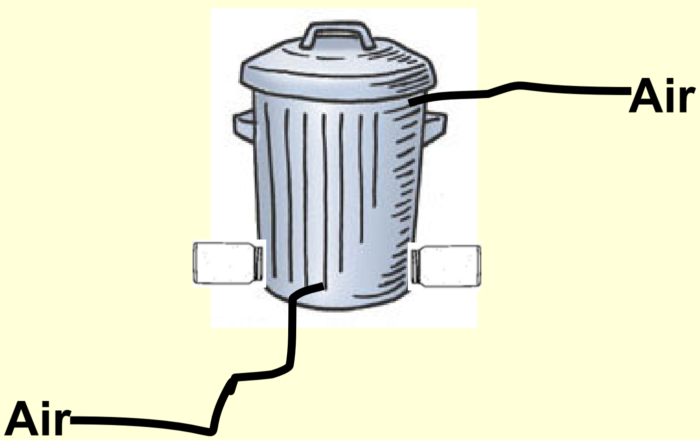
**The importance of humidity in life of ambrosia beetles.**



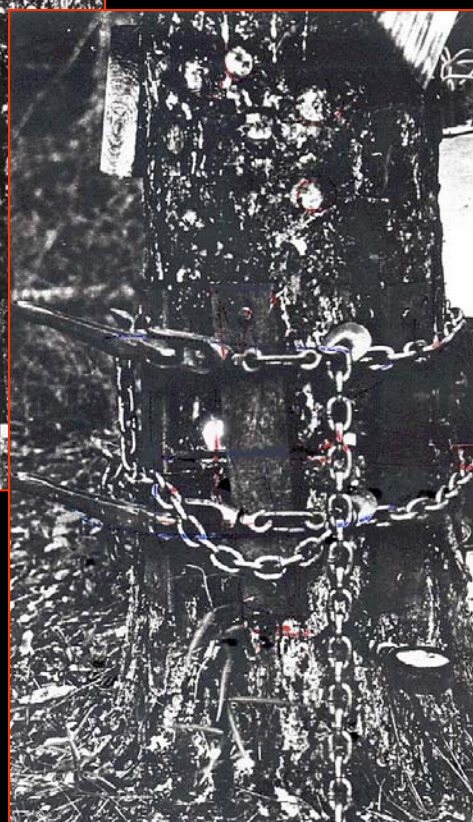
# Establishing the BTI lab near Sour Lake, Texas

# Rearing the southern pinebeetle in winter

SPB-rearing house
at BTI lab




USFS 33gal SPB-rearing
system



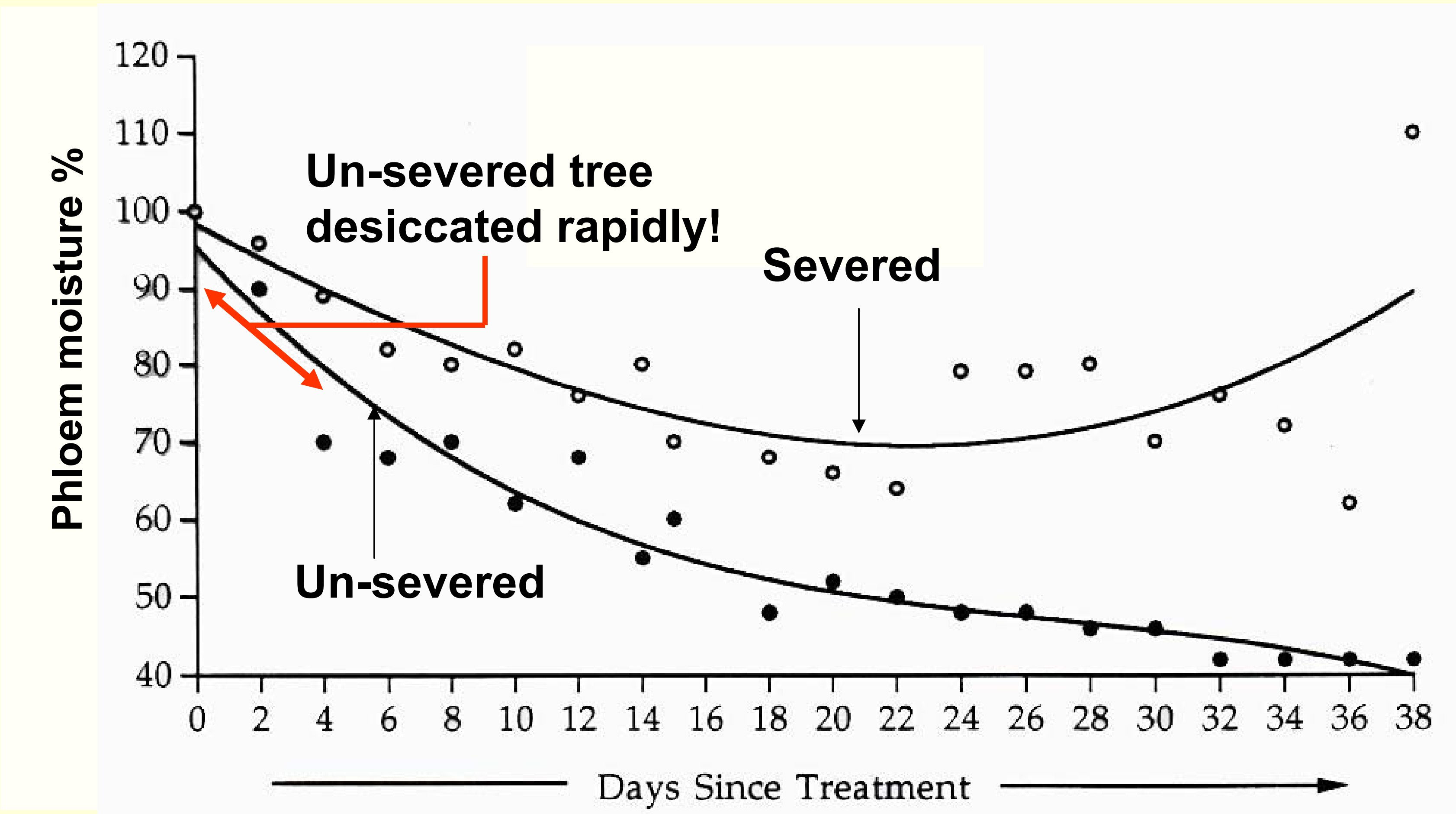
A severed loblolly pine and an un-severed pine:

• a circular plug was cut out of each tree twice a day;

• the phloem temperature and moisture content were determined for each plug.

• both trees were baited with the SPB pheromone.

**Ultimate Results**: SPBs didn't survive in the severed tree – broods were drenched and covered with mold

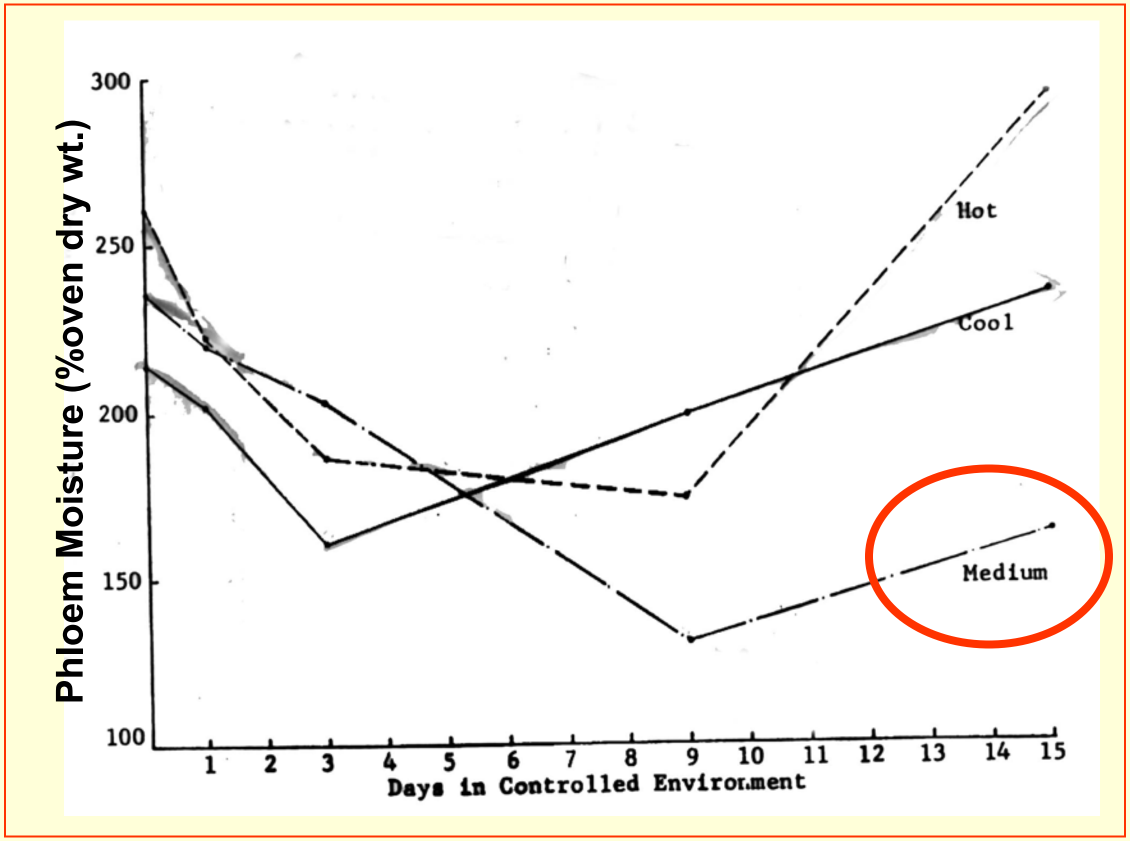


## SPB emergence holes as well as “respiration holes”

As they cut their egg galleries they also punch out these “respiration holes” – really to obtain a fast desiccation rate of the phloem

# Rearing SPB in logs represented a medium temp/humid regime

Rearing chamber



# Medium SPB rearing regime



TABLE 3.—Effects of regimes maintained in environmental chambers on emergence time, pupal weight, and increase ratio of *D. frontalis* broods

| Regimes | | No. of beetles | | Average emergence time, days | Average pupal wt., 0.1 mg. | Ratio of increase |
|---|---|---|---|---|---|---|
| Temperature, ° C. | R.H., % | Attacking, sq. ft. | Emerging, sq. ft. | | | |
| 14–16 | 60–70 | 26.5 | 172 | 46 | 31 | 3.24 |
| 20–22 | 60–70 | 24.5 | 131 | 31 | 24 | 2.67 |
| 20–22 | 50–60 | 27.4 | 215 | 31 | 27 | 3.93 |
| 26–28 | 40–50 | 28.8 | 149 | 30 | 22 | 2.58 |
| 34–36 | 40–50 | 26.9 | 177 | 29 | 21 | 3.28 |
| 34–36 | 40–50 | 25.4 | 137 | 26 | 22 | 2.69 |
| 40–42 | 30–40 | 18.6 | * | * | — | — |
| 44–46 | 10–20 | 23.8 | ** | ** | — | — |

# Mortality-factor: nutritional – (1) food quantity

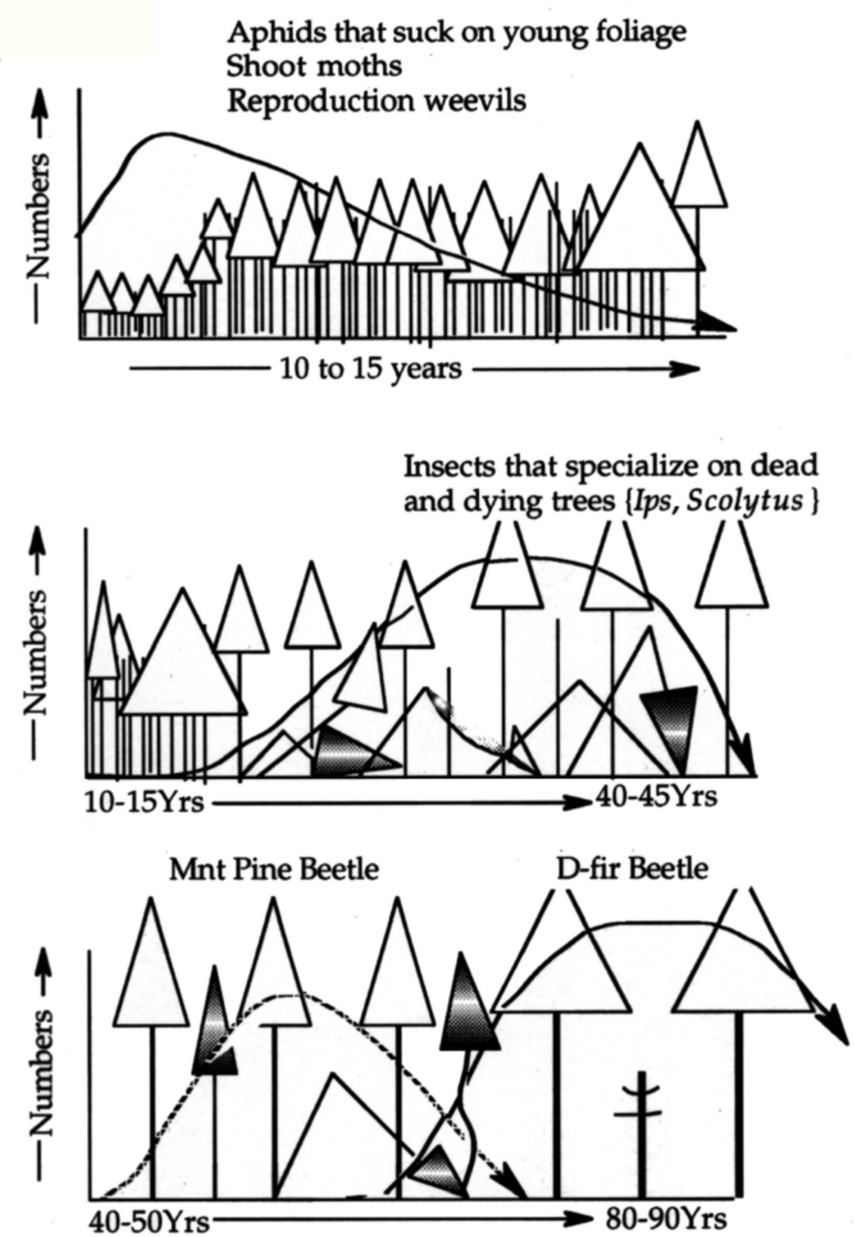

**The quantity of food available to forest insects is really a function of forest-succession. This being the case, inspired forest management can often lower the impact of insect damage.**

*Functional Stages of a forest*

**Regeneration:**
- competition
- mortality

**Suppression:**
- crown closure
- suppression
- mortality

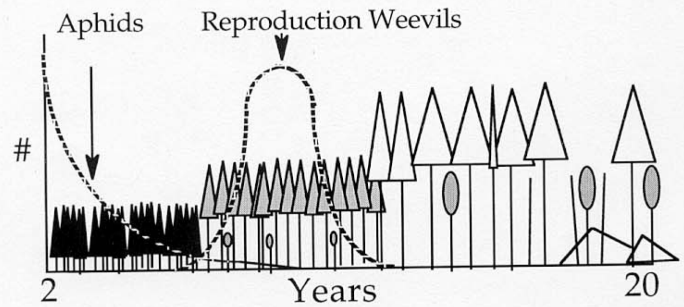
**Species shift:**
- suppression
- gap formation
- late successional development



## Reproduction Stage

### Nutritional Env. Resistance Factor -- Food Quan.

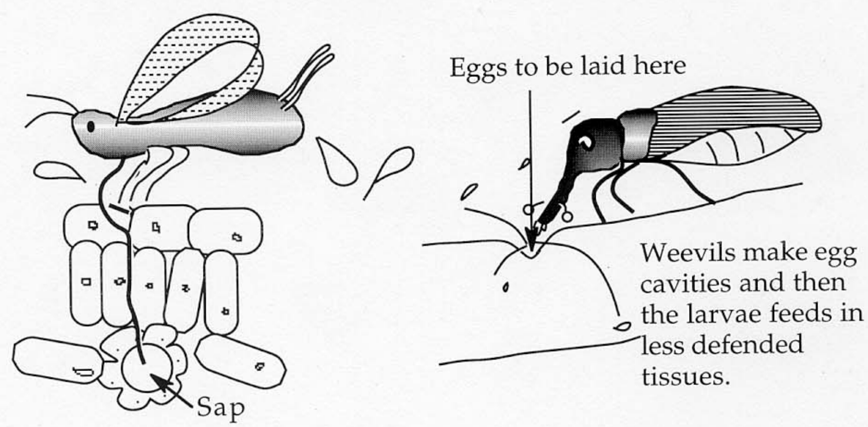
Food Quantity = *f* (Successional Dynamics, Susceptibility of hosts/ host defense systems, Rapidity of growth *etc.*).




Why? Aphids and weevils?

(1) Hosts have invested in having fast-developing juvenile growth

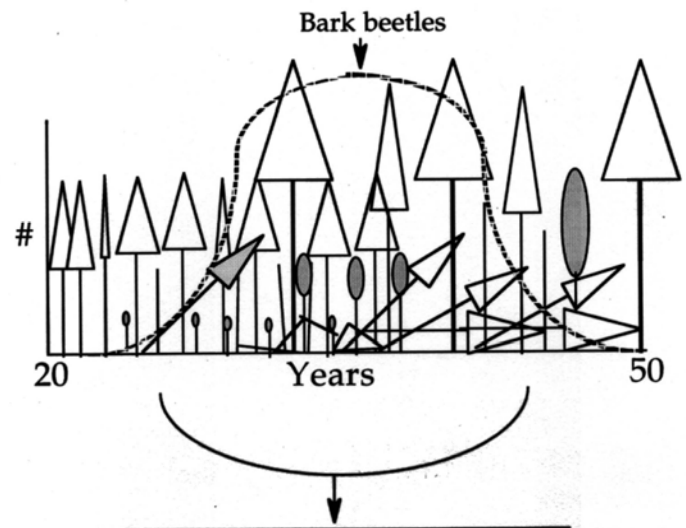
(2) Juvenile foliage has qualitatively toxic compounds.



## Suppression Stage

### Nutritional Env. Resistance Factor -- Food Quan.

Food Quantity = *f* (Successional Dynamics, Susceptibility of hosts/ host defense systems, Rapidity of growth *etc.*).




There is major competition for light as trees take dominance and some are left behind and **weaken.**

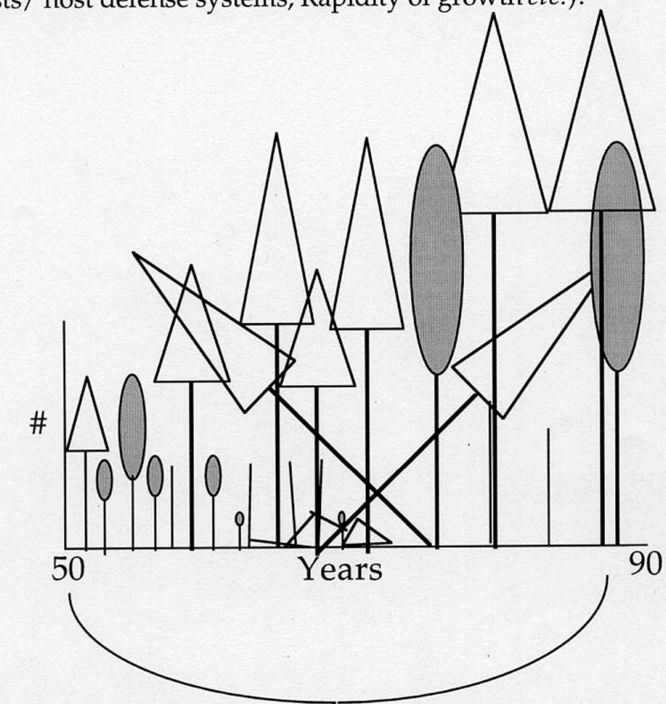
The weakened trees and moribund and recently dead trees are susceptible to the bark beetles: *Ips*, *Scolytus*, *Pseudohelesinus*, and many others.

As stand closure occurs the dominant and codominant "winners" invest energy in defending themselves with high-cost defensive chemicals: resins, phenolics, and tannins.

## Species-shift Stage

### Nutritional Env. Resistance Factor -- Food Quan.

Food Quantity = *f* (Successional Dynamics, Susceptibility of hosts/ host defense systems, Rapidity of growth *etc.*).




What are the major stand issues that deal with stand susceptibility? Hmm?

- Density/drought relationships
- The fire history
- Silvicultural/logging history

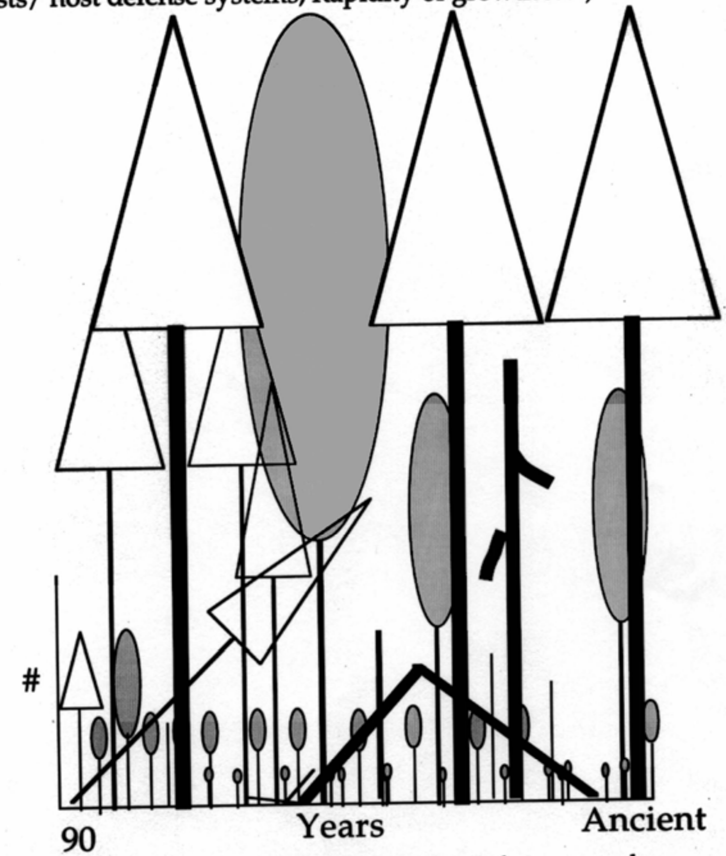
**Pine Forests -- Mountain pine beetle**

**Douglas-fir Forests -- Douglas-fir beetle (wind throw)**

# Oldgrowth Stage

## Nutritional Env. Resistance Factor -- Food Quan.

Food Quantity = *f* (Successional Dynamics, Susceptibility of hosts/ host defense systems, Rapidity of growth *etc.*).

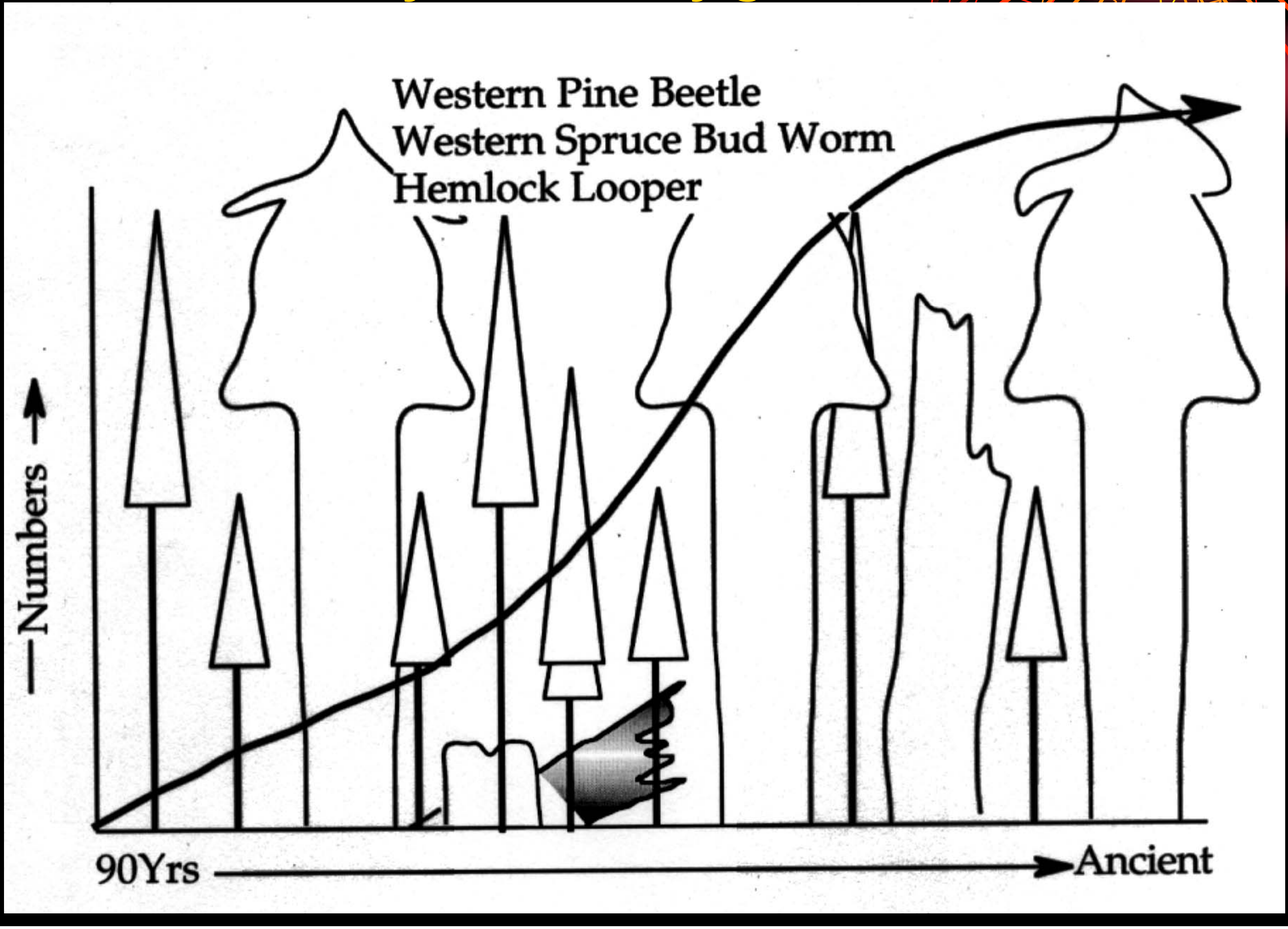



The old/large pioneering species cannot produce enough photosynthates (energy) for maintenance of biomass !! Now, that's a **big problem**!!

- Reduced foliar defenses
- Reduced subcortical defenses (sapwood/phloem interface)
- Reduced growth

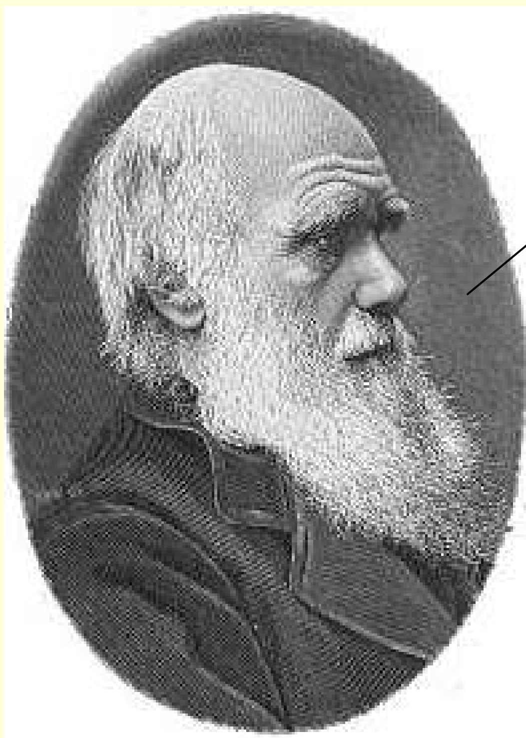
Root rots!, Western pine beetle, Western spruce bud worm, Hemlock looper & D-fir tussock moth.

When old pioneering species or simply old late-successional species are not producing enough carbohydrates, they get in trouble.



# Mortality-factor: nutritional – (2) food quality

**There's a great example of food quality being important in "survival of the fittest" with barkbeetles.**



**Barkbeetles generally live in phloem tissues of weakened, unhealthy trees: a temporary habitat!**

**What does that mean?**

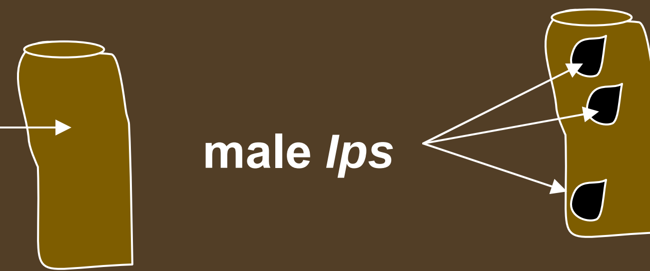
- **Most barkbeetles normally find and breed in phloem of logging slash, windthrows, water-stressed trees, the moribund (e.g. trees damaged by fire) etc.;**

- **When this kind of food material occurs, it's scattered all over the landscape, and;**

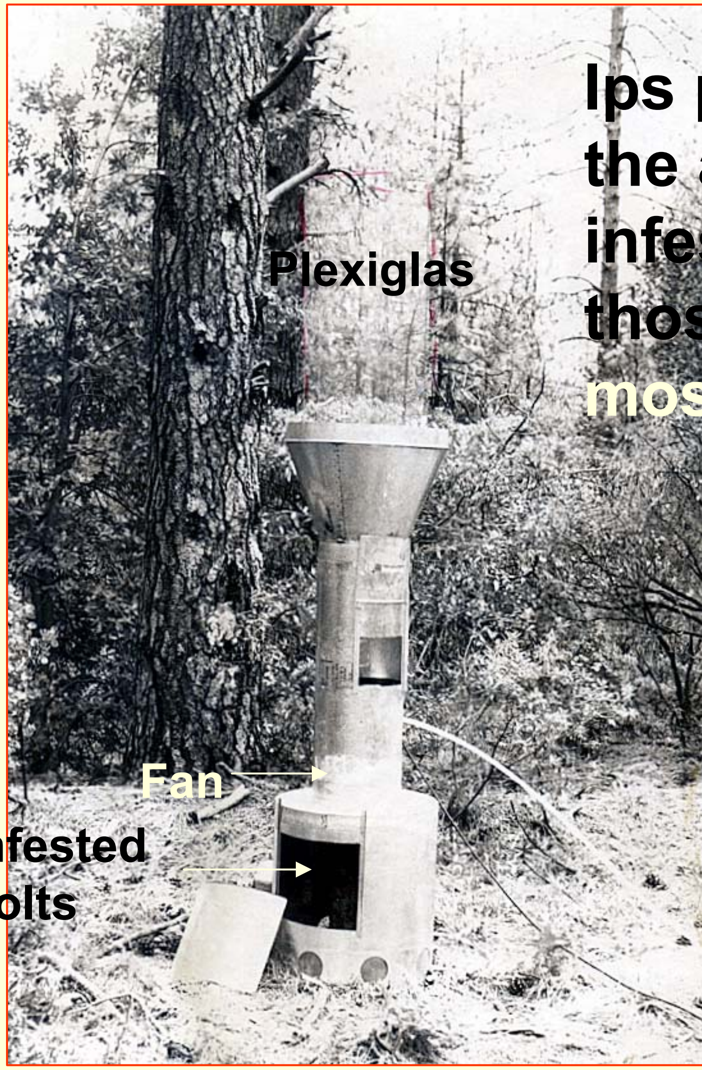
- **This food is drying out, or fermenting, or otherwise becoming unsuitable.**

- **Thus, the main task of barkbeetles is to quickly find and breed in this kind of host material. They have a tough task!**


**Bolt cut above the gall**



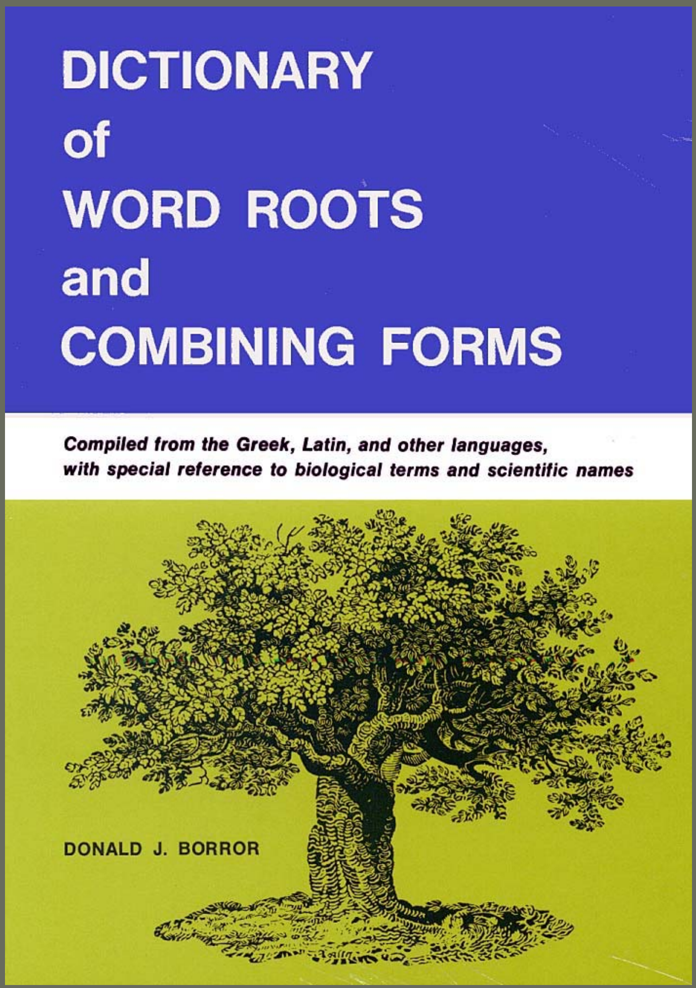

**Bolt cut below the gall**




**Ips pheromone wafts out into the atmosphere. Question: Did the infested bolts from above the gall or those from below the gall attract the most *Ips*?**

**<u>Ans</u>.: the phloem above the gall had a greater concentration of carbohydrates than the phloem from below the gall. Hence, *Ips* males that fed on higher quality phloem made a more powerful pheromone.**

Of course, the quality of plant material to herbivores has a lot to do with defensive chemicals that trees have evolved. This brings us into the world of Semiochemicals.

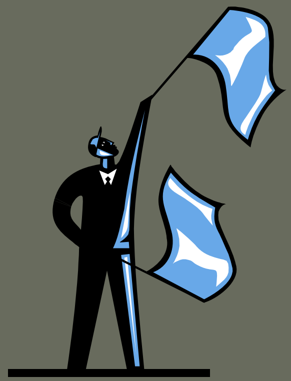



1. semio – (L), signal

2. semiochemicals – "…all chemicals produced by an organism that incite a response in another organism."

# Semiochemicals

- Intraspecific
  - Pheromones
- Interspecific
  - Allelochemics
    - Receiver advantage
      - Kairomones
    - Emitter advantage
      - Allomones
        - Next Page
    - Advantage to both
      - Synomones



## Some Allomones

- Repellents
- Feeding deterrents
- Growth regulants

**There probably are millions of compounds that have evolved as allomones, *e.g.:***

- the nitrogen based alkaloids
- terpenoids
- phenolics
- proteinase inhibitors
- insect growth-hormone mimics

# Semiochemicals

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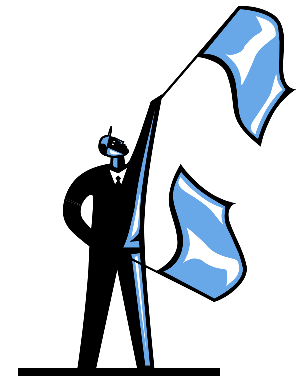

## Some Allomones

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- the nitrogen based alkaloids
- terpenoids
- phenolics
- proteinase inhibitors
- insect growth-hormone mimics

# Nitrogen Based Allomones

**Many are *non-protein* amino acids: insects feeding on these convert them into strange, unusable proteins. Many of these compounds are perceived by insects as feeding deterrents.**

## Nonprotein Amino Acids[1]: Preparation of 5-Substituted-2-Aminoadipic Acid Derivatives

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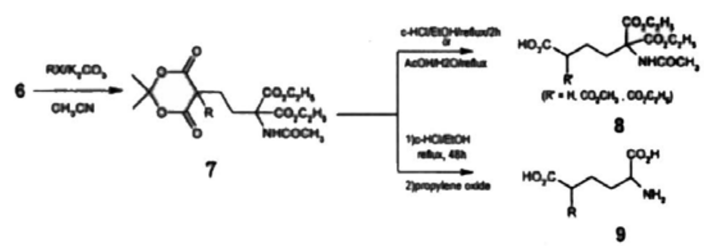
*Received August 13, 1998*

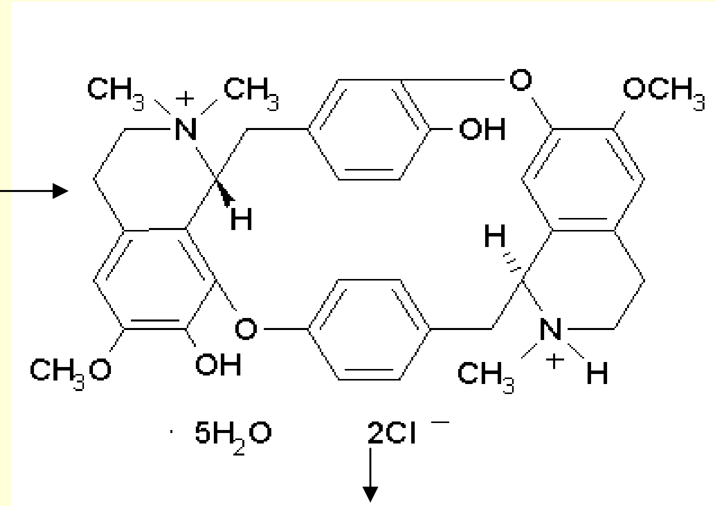
The number and structural types of nonprotein amino acids[2] have increased dramatically over the past few decades. Some of the synthetic amino acids and nonprotein amino acids found in several plants exhibit interesting biological activities. For instance, methionine sulfoxamine (**1**)[3] and phosphinothricin (**2**)[4] serve as herbicides, fluorine containing amino acids as suicide enzyme inhibitor, β-cyanoala-



# The Alkaloids

**Plants often produce complex nitrogenous poisons:**

- nicotine
- tomatine
- hellebore
- curare
- cocaine
- atropine
- morphine
- heroin
- many, many others




- Alkaloids are nitrogenous compounds and many are amino acid derivatives -- many are well known poisons;

- Nicotine has a long history as an insecticide;

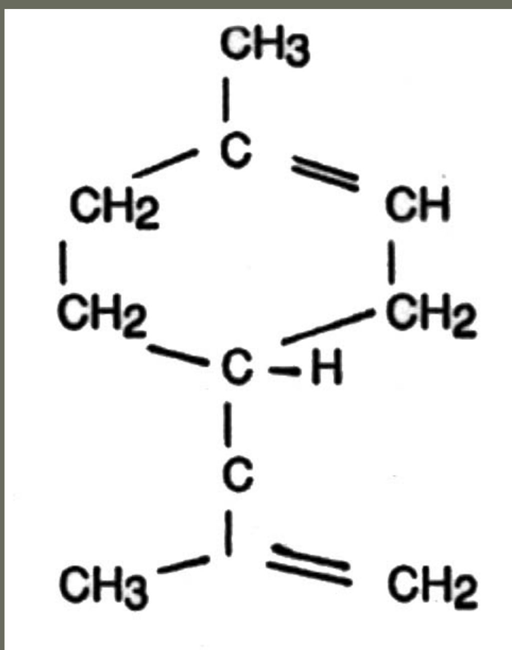
- Tomatine is found in many Solinaceae; potatoes bred to contain tomatine are resistant to suite of herbivores.

- Some insects such as the cinnabar moth are immune to alkaloids – in this case, to the invasive ragwort.

Ragwort contains alkaloids that protect plants from many herbivores. When the cinnabar moth was introduced to the PNW it started to wipe out the ragwort: a case of effective biological control!

# Terpenoids (non-nitrogenous, 5 carbon chains of hydrocarbons)

$$CH_2 = \underset{\displaystyle CH_3}{\underset{|}{C}} - CH = CH_2$$



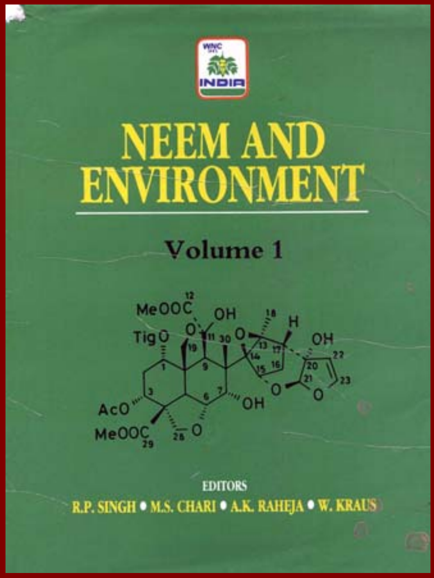

an isoprene unit
"puppy"

-limonene
-$\Delta_3$ carene
-β pinene
-α pinene

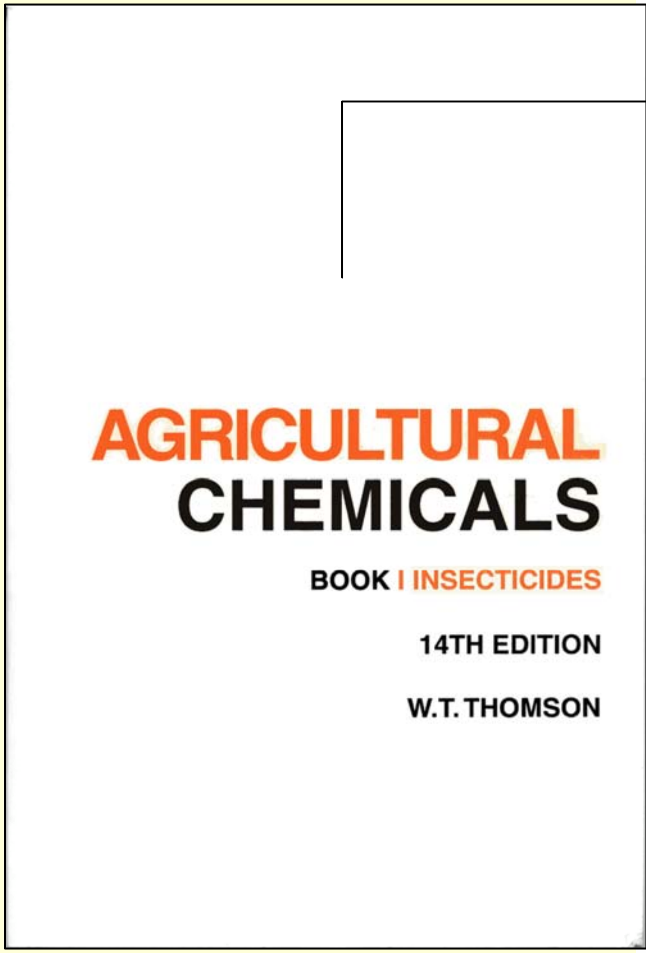
Chrysanthemum plantation as a source of pyrethrum.

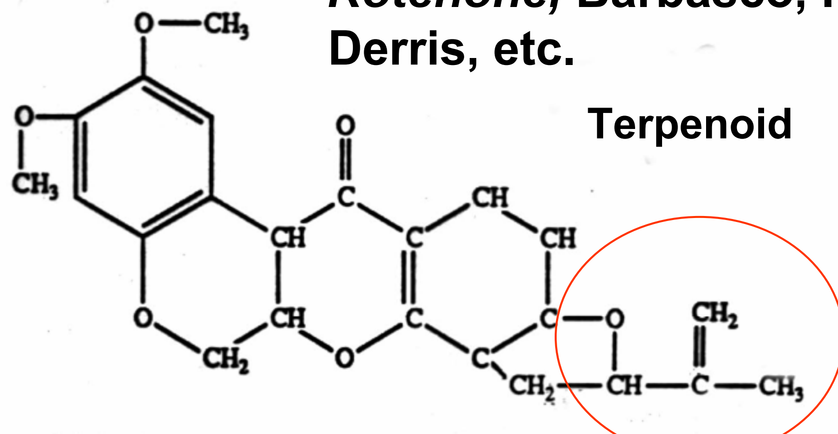
Other terpenoids, such as gossypol provide major defense against herbivores, e.g. resistance to bollworm in cotton is directly proportional to gossypol content.  Of course, companies producing cooking oils from cotton seed would want low concentration of this terpenoids.

Extracts from neem trees have a huge series of complex terpenoids.  There is a terpenoids that kills insects at concentrations of 0.04ppm.




## *Rotenone,* Barbasco, Ro-Ko, Derris, etc.



Terpenoid

**1,2,12,12a,Tetrahydro-2-isopropenyl-8,9-dimethoxy-(1) benzopyrano-(3,4,-6)furo(2,3-6) (1)benzopyran-6(6aH) one**

**TYPE:** Rotenone is a botanical insecticide having both contact and stomach-poison activity.

**ORIGIN:** First used on crops in British Malaya in 1848. England patented it in 1911. The chemical nature was determined in 1932. Sold in the U.S. by Fairfield America, Prentiss Drug, Penick and Co., and others. Supplied by Foreign-Domestic Chemicals, Inc.

**TOXICITY:** $LD_{50}$-132 mg/kg. Very toxic to fish. Swine are highly susceptible.

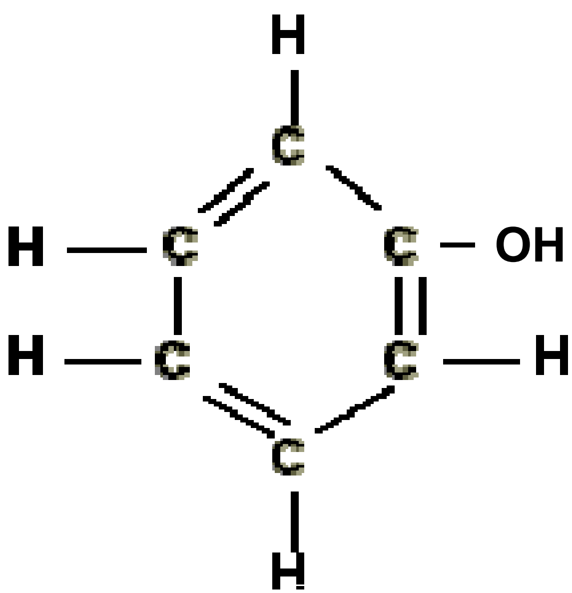
**FORMULATIONS:** Dusts 1/2-1%, 4-5% WP.

**PHYTOTOXICITY:** Non-phytotoxic.

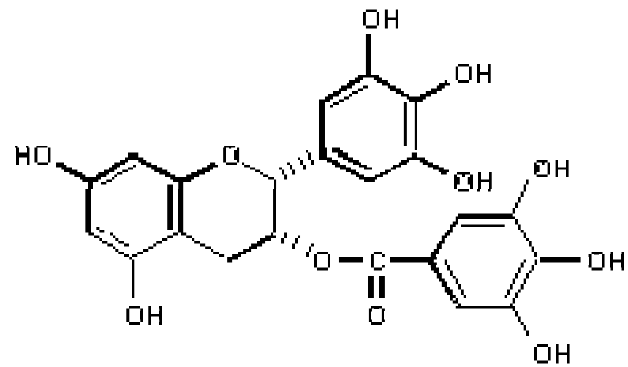
**USES:** Bush and vine crops, citrus, deciduous fruits, forage crops, mushrooms, asparagus, beans, beets, corn, eggplant, mustard, peas, potatoes, radishes, strawberries, tomatoes, and other vegetables. Also used to control undesirable fish.

## The Phenolics

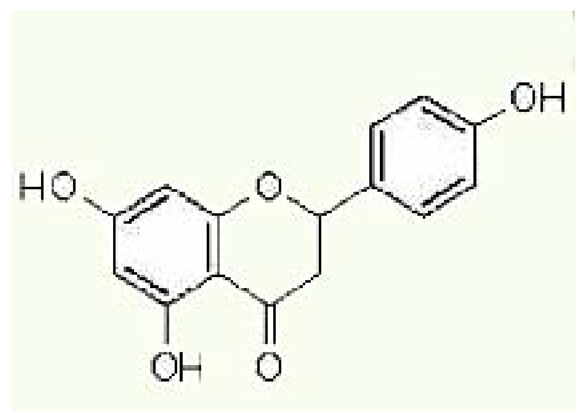
**A basic phenolic is simply,**




**…a non-nitrogenous compound containing one or more hydroxyl on the benzene ring.**




**Tannins**




**Flavonoids**

## (Continue the Phenolics)

- There are lots of botanical insecticides and commercial feeding deterrents based on flavonoids.

- As insects ingest tannins, these compounds chemically tie up proteins and make them indigestible.

- Over evolutionary periods, insects begin to resist the effects of tannins and use them in providing interesting defensive strategies.

- Witness emerald moth larvae feeding on oak foliage.

## Emerald moth, *Nemoria arizonaria*


1. Caterpillars born in spring feed on oak catkins; within days they look like fuzzy catkins,

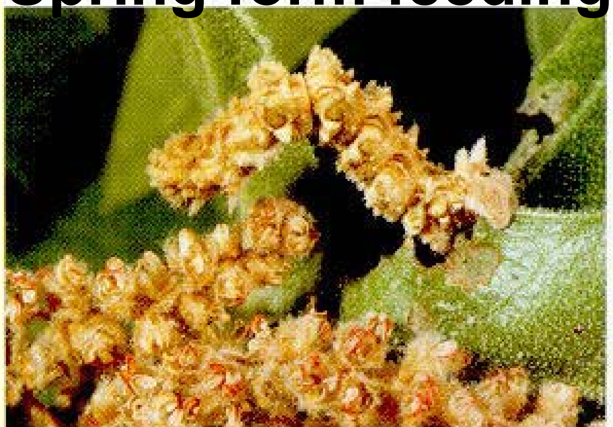
2. Caterpillars born in summer (after catkins fall off) eat leaves and look like oak-twigs.

3. Only oak leaves are loaded with tannins.

4. When tannins are sprayed on catkins and fed to fuzzy larvae they begin to look like twigs!

## Clearly a case of, “you are what you eat.”

**Spring form feeding on catkins**



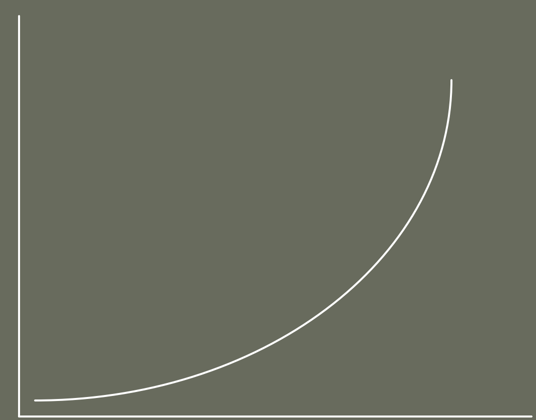
**Summer form feeding on leaves**

fed tannins extracted from foliage

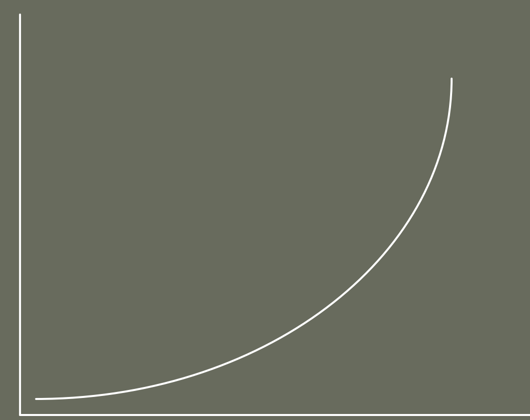
Oaks invest energy in their foliage in order to produce tannins, a defensive chemical.

## Lab in Kinkaid

Dr. Davey Rhoades



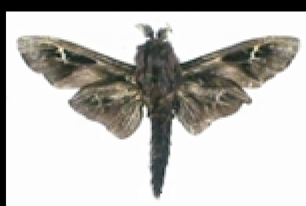

## Storage room in Kinkaid where red alder were stored



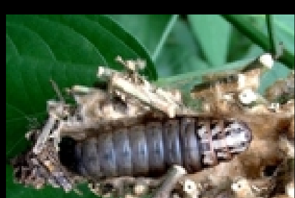
1989 there was a huge insect defoliation of mangrove trees in estuaries around Guayaquil, Ecuador.

**“… I was there.”**

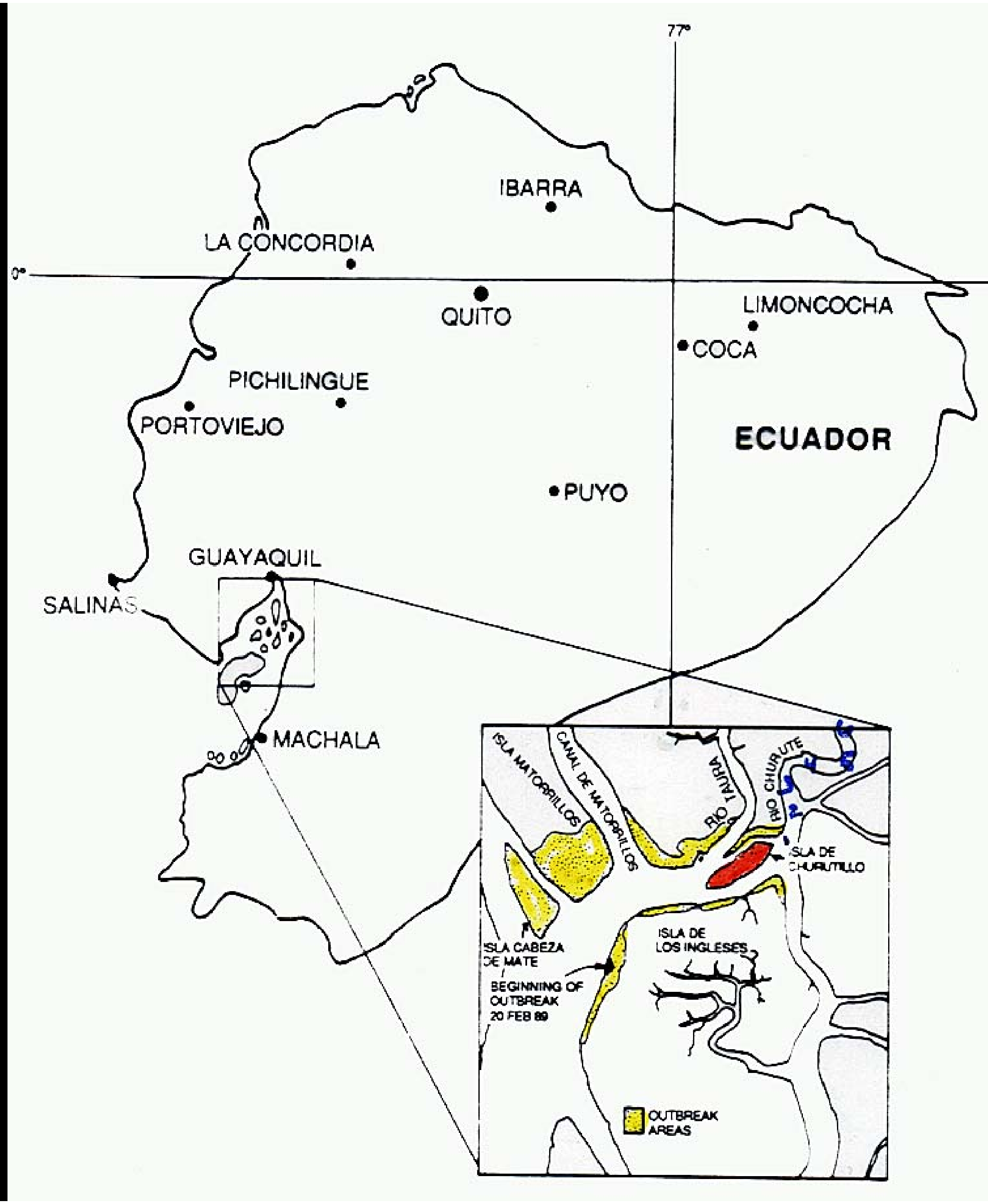
**1989-90 outbreak of the bagworm, *Oiketicus kirbyi*, in mangrove forests near Guayaquil.**



Male



Female



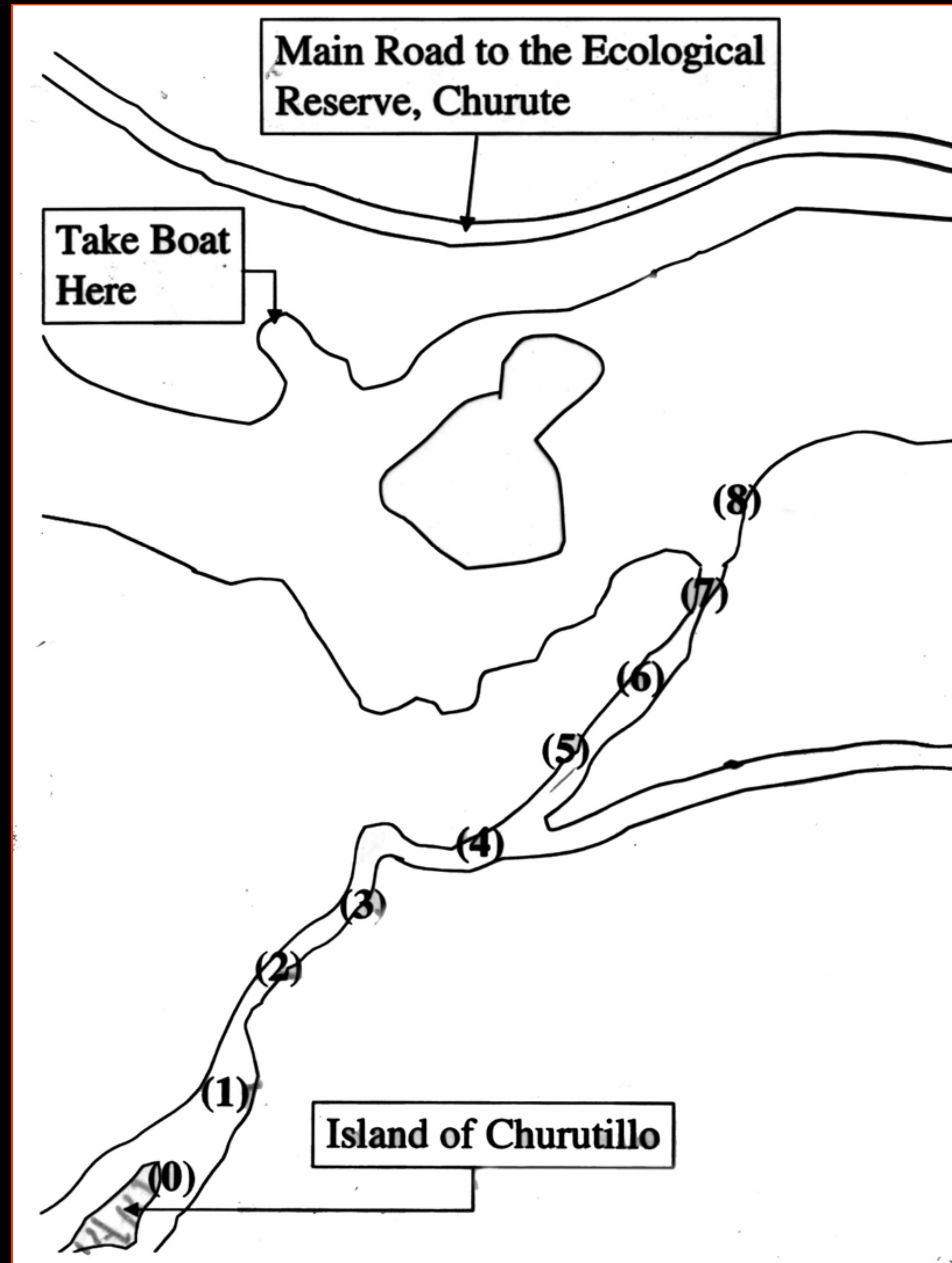
**Mangrove ecosystems of Ecuador systematically being destroyed by the shrimp industry.**

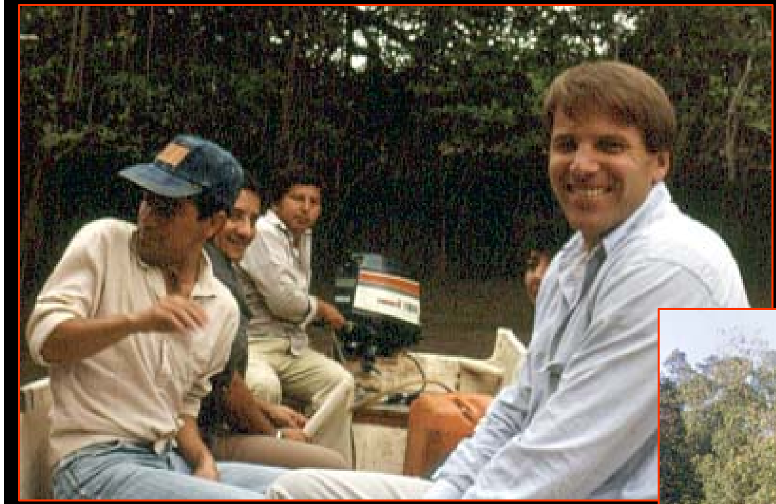
## Severe bagworm defoliation of the mangrove forests of Churute Ecological Preserve

**Establishment of eight sampling stations (1km apart) for *O. kirbyi* .**

**Station (0) was at the island of Churutillo, the most intense of the defoliation.**

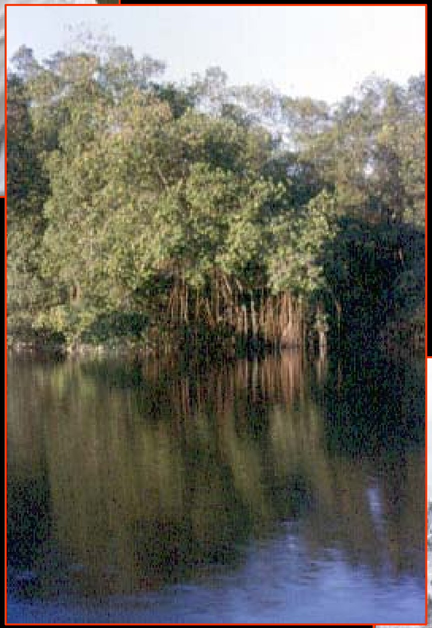
**Station (8)(8km from Churutillo) was the least defoliated.**





**Boating down the Rio Churute towards the epicenter of the outbreak on the island of Churutillo.**

**Station (8): barely defoliated by *O. kirbyi.*** →



**Station (5): medium defoliated by *O. kirbyi.*** →

**Station (3)**

**Isla Churutillo is almost totally defoliated**

**Feeding bagworms**

Collecting bagworms at Isla Churutillo

Checking for parasitism

Bagworms feeding on bark (foliage all gone)

## Rearing the bagworms at the lab in Conocoto (near Quito)

**Table 1.** Emergence, pupal weights of males (M) and females (F) as well as survival of *O. kirbyi* larvae (L), pupae (P) and adults (A) as determined from laboratory rearings of material collected from mangrove forests of the Ecuadorian Ecological Reserve of Churute

| Date | Numbers | | | | | | Dying (%) | Males (%) | Weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dead | | | Alive | | | | | | |
| 1989 | L | P | A | L | P | A | | | ♂ | ♀ |
| 7/20 | 22 | 36 | 2 | 3 | 16 | 14 | 65 | 52.1 | 0.45 | 1.17 |
| 8/17 | 63 | 97 | 10 | 12 | 30 | 16 | 74 | 91.4 | 0.28 | 0.54 |
| 9/11 | 82 | 107 | 2 | 15 | 8 | 0 | 89 | 100 | 0.20 | — |

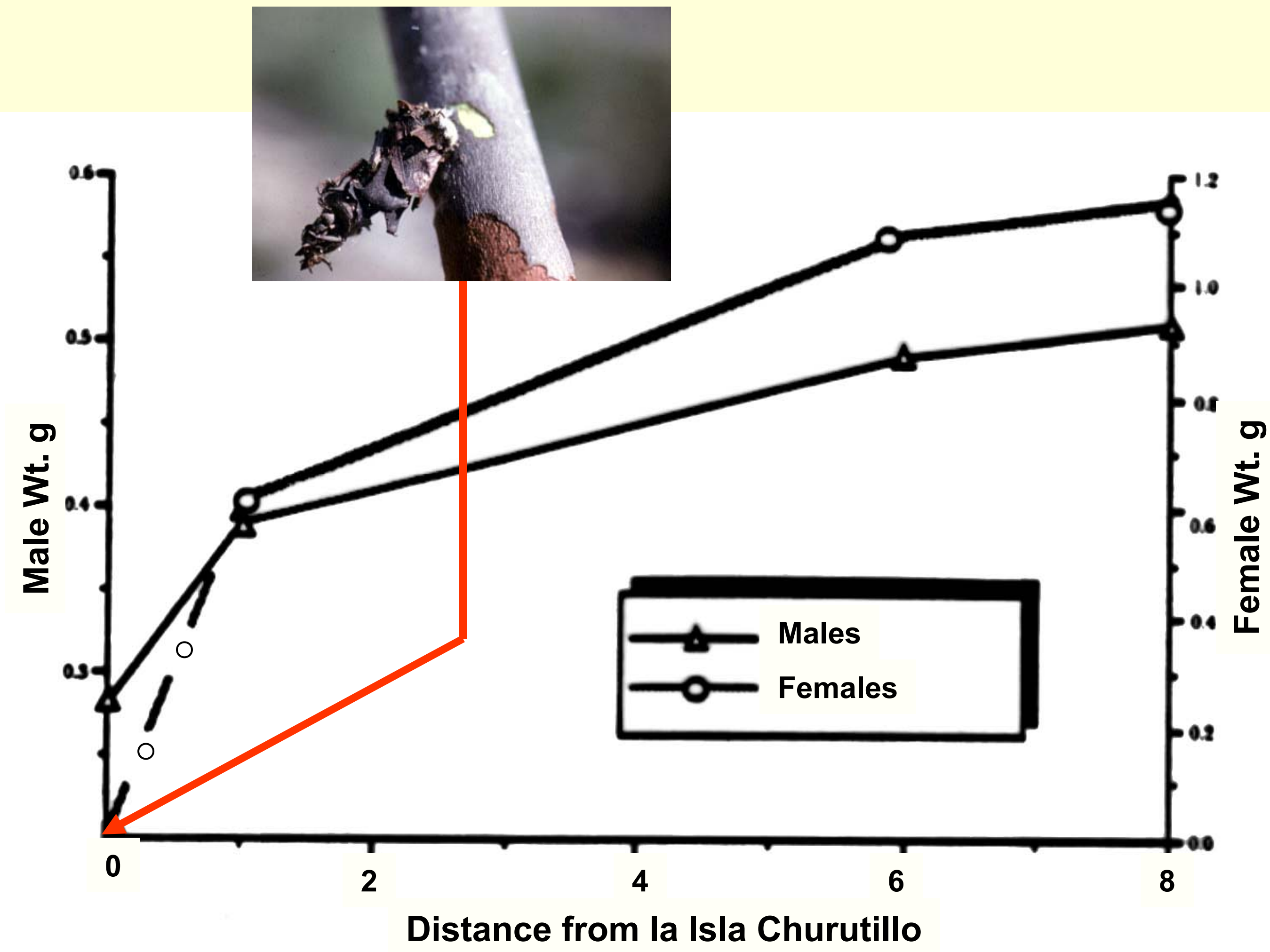



**Figure 3**. Decrease in weight of male and female *O. kirbyi* pupae reared from sites 8, 6, 1 and 0 *km* respectively from the Island of Churutillo, the most heavily defoliated area; no female pupae were collected from the island

A great amount of research on the tannins of mangrove species

Polymer International

Polym Int 49:574-578 (20

# Differential scanning calorimetry of hydrolysed mangrove tannin

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[2] Department of Chemical Engineering, University of Benin, Benin City, Nigeria

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**Abstract:** Mangrove-bark-tannin adhesives are potential substitutes for phenol-formaldehyde (PF) wood-bonding adhesives which are derived from petroleum, a finite natural resource. However, mangrove-bark-tannin adhesive exhibits poor adhesive properties, including brittleness, poor wet strength, and poor wood penetration. These shortcomings are due to its high reactivity and structural features. To reduce these shortcomings, the structure of the adhesive was modified by subjecting tannin to (a) caustic hydrolysis and (b) consecutive acetic anhydride and caustic hydrolysis. The effectiveness of these hydrolyses was determined by using differential scanning calorimetry (DSC) to monitor the reaction and cure characteristics of hydrolysed and unhydrolysed tannin with formaldehyde. These hydrolyses resulted in lowering both the activation energy and collision frequency of the cure reaction. Consequently, the initial reactivity of tannin towards paraformaldehyde, which was usually very high, was reduced. The resulting longer reaction time enhanced the extent of reaction, as was evident in the increase in heat of reaction of the hydrolysed tannin.





## Chemistry

Wood contains 4.4% resin, 63.4% cellulose (List and Horhammer, 1969–1979) and 1.5% ash (Watt and Breyer-Brandwijk, 1962). Tannin may vary in dry bark from ca 13–50%, leaves contain 9.1%, green fruits 12.0%, and ripe fruits 4.2%. Spent mangrove bark, after tannin extraction, can be used as a source of furfural (C.S.I.R., 1948–1976).

**There also are proteins, called Proteinase Inhibitors, that bind to insectan proteinases and immobilize them so that normal proteins can't be digested. Insects thus starve to death.**

*Pure & Appl. Chem.*, Vol. 66, No. 1, pp. 1–7, 1994.
Printed in Great Britain.


# Invertebrate proteinase inhibitors

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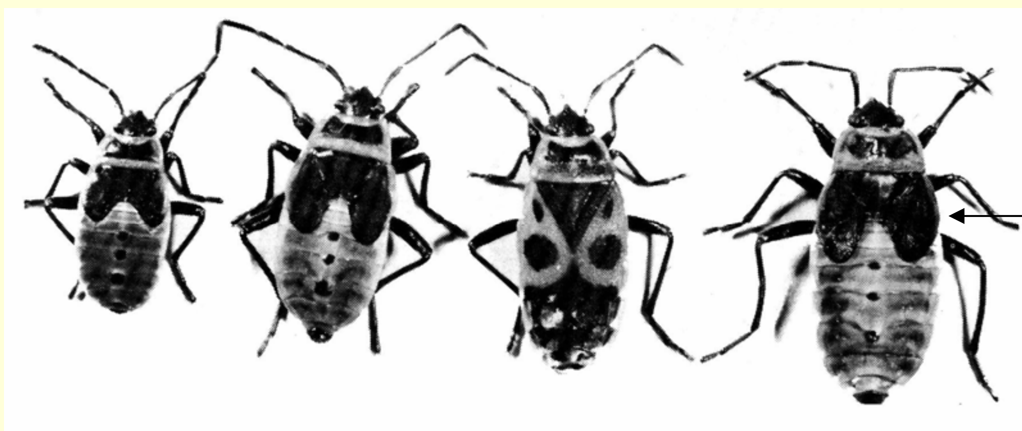
***Abstract***

Peptides with inhibiting activity toward proteinases were isolated from marine invertebrates, insect plasma and nematodes. Some of them were characterized and studied in relation to their physiological function.

**There are plant extracts that mimic insectan juvenile hormones and ecdysone. these hormones suppress formation of adult characteristics. Ferns in general have the equivalent of ecdysone produced by 200,000 larval moths – few insects feed on ferns.**

**Accidental Science by Karel Slama: rearing the bug *Pyrrhocoris apterus* led to break through research on juvenile hormones.**



**This should have been the adult stage!**

"All the News That's Fit to Print"

The New York Times.

LATE CITY EDITION

JOHNSON SWAMPS GOLDWATER AND KENNEDY BEATS KEATING; DEMOCRATS WIN LEGISLATURE

The Election at a Glance

Democrats Are Assured Of Majorities in Congress

3AM EDITION THE BEST ELECTION NEWS, COMMENT AND RESULTS

THE TIMES

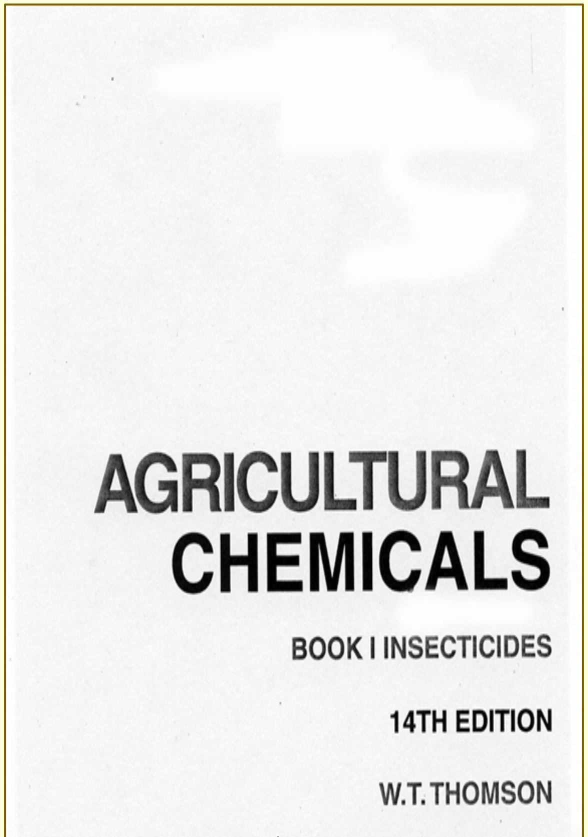
SOUNDS 15

The Gypsies pitch up

HIT & MYTH
Bob Stanley

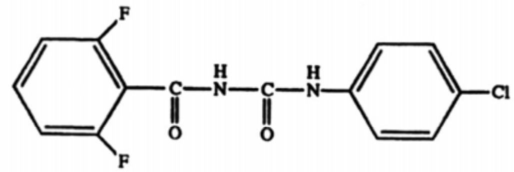
Wild Balkan music is electrifying the New York club scene, reports Nina Roberts

Pyrrochorids reared on the New York Times exhibited the strange instar, but when reared on the London Times the last instar was normal and molted to the adult stage. The NY Times is made from balsam fir and the London Times from European fir – the famous "paper factor."




**NAMES**

***DIFLUBENZURON***, **ADEPT, DIFLURON, DIMILIN, DUDIM, KITINEX, LARVAKIL, MICROMITE, VIGILANTE**



**N-[[(4-chlorophenyl)amino]carbonyl]-2,6-diflouorobenzamide**

TYPE: Diflubenzuron is a benzoylurea-type compound interfering with chitin deposition.

ORIGIN: DUPHAR B.V., The Netherlands; 1972. Marketed in the US by Uniroyal Chemical Co. for crop uses, and by Hoechst for livestock application (cattle bolus).

TOXICITY: $LD_{50}$ 4640 mg/kg. May cause slight eye irritation.

FORMULATIONS: 2 - 4 lb. flowable, 25 WP.

PHYTOTOXICITY: Non-phytotoxic at the recommended rates and uses. High rates have caused injury to poinsettias, hibiscus and Reiger begonias.

USES: Larvicide in forestry, on pastures and rangeland, ornamental trees, mushroom houses, walnuts, artichokes, citrus, cotton, soybeans and ornamentals. Used against mosquito and fly larvae in non-crop areas. Used outside the U.S. on these and a number of additional crops. Used as a feed through additive on livestock outside the U.S.

IMPORTANT INSECTS CONTROLLED: Gypsy moth, boll weevils, army worms, leafworms, soybean caterpillar complex, cabbage caterpillars, Mexican bean beetle, mosquitoes, flies, sciarid flies, rust mites, leaf miners, codling moth, grasshoppers, fleas, cockroaches, lice and others.

RATES: Applied at 0.02-0.125 lb a.i./A.

APPLICATION: Apply around oviposition time of adults for ovicidal activity or at early larval instar stages for larvicidal activity. Thorough coverage is necessary. Apply as a foliar spray or as a soil drench.

PRECAUTIONS: No effects on adult insects. Toxic to crustaceans. Do not mix with alkaline compounds.

ADDITIONAL INFORMATION: This product interferes with the formation of the insect's cuticle. Active on the larval stages of development, causing an inability to moult successfully. Does not enter the plant, so sucking insects are not controlled. Ovicidal activity, either directly on the eggs or by action through the female. Feeding will continue for a short time after application (until the next moult), so results may not be visible immediately. Has a long residual activity with both stomach poison and contact activity. Relatively harmless to beneficial insects. Provides 30-60 day control. Compatible with other insecticides.