Insecticides

Objectives

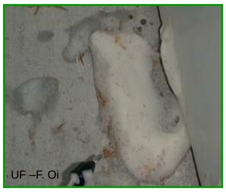
1. Relate four major events in the history of Pest Control
2. Describe the major types of insecticides and give an example of each
3. Describe in detail how organophosphates and carbamates interfere with the normal functioning of the nervous system.
4. Describe how toxicity of insecticides is measured
5. Discuss the advantages and disadvantages of insecticides

Introduction

Insecticide: chemicals that kill insects.

Pesticide: broader term meaning a killer of pests in general (fungicides, herbicides, miticides, rodenticides, avicides, insecticides, etc.).

Foam treatment for drywood termites in a door.



termite frass in foam.

Brief History of Pest Control

- **2500 B.C.** - Sumerians began using sulfur as an insecticide.
- **800 B.C.** - Chinese and Egyptians used herbs and oils to control insect pests.
- **300 B.C.** - Chinese monitored pest emergence and regulated planting dates.
- **1100-1600 A.D**. - Chinese used soaps, tobacco and arsenic to control pests.
- **1800's** - Countries regulated and quarantined goods for inspection before unloading.
- **1899 –** The first major biological control success: cottony cushion scale in California.

The cottony cushion scale insect almost destroyed the citrus industry in California during the late 1800's. Albert Kebele was sent to Australia and found Vidalia beetles feeding on it. He brought back a population and released the beetles in California.

Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services

Brief History of Pest Control (continued)

1939 - "Insecticide Era," synthetic insecticides were developed.

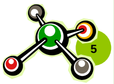
The importance of this event was quickly manifest with the outbreak of WWII. Stop and think for a moment what connection may exist between WWII and insecticides.

Hint: it has nothing to do with using chemicals to poison people.

Up until WWII insect born diseases such as epidemic typhus and malaria, which can run rampant during warfare, generally took more lives than enemy fire.

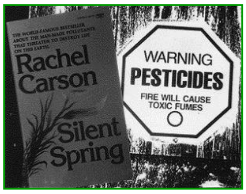
DDT effectively controlled both the lice that spread typhus and the mosquitoes that spread malaria.

All research being done on biological control and other ways to control pests was stopped and all resources and energy was directed toward developing new and better insecticides.



History (continued)

1962 - Rachel Carson's book, *Silent Spring,* brought attention to the dangers of insecticides.



Responding to this environmental awareness, government regulation on pesticide use increased and public perception of insecticides began to change.

It was found that DDT accumulated in the environment, damaged raptorial bird populations, and stimulated resistant populations of insects.

Eventually it was banned in the U.S.

History (continued)

Since then…

Pest Management has become the ideology, not pest elimination.

The goal was now to manage the pests to prevent their numbers from reaching the EIL.

In Pest Management industry, exterminators are now known as PMPs or pest management professionals.

Chemical Control

Modes of entry	Modes of action
•Contact •Ingestion •Systemic •Inhalent	•Ach.E. Inhibition •Nerve poison •Hormone disruptor

Insecticide Labels

Bayer Environmental Science

Merit® 0.5 G Insecticide

For systemic insect control in turfgrass and landscape ornamentals.

ACTIVE INGREDIENT:
*Imidacloprid, 1-[(6-Chloro-3-pyridinyl)methyl]-*N*-nitro-2-imidazolidinimine 0.5%
OTHER INGREDIENTS: 99.5%
100.0%

*Protected by U.S. Patent No. 4,742,060

EPA Reg. No. 432-1328 EPA Est. No. ___

Common name - specific name given to the active ingredient; similar to the scientific name of an insect.

Chemical name - describes the chemical compound structure.

Trade name - (on this label is "Merit 0.5 G") the commercial name given by the company producing the insecticide.

Label Activity

Take a look at label 2

What is the common name for this pesticide?
What is the trade name?
What is the chemical name?

Understand the difference between common, trade and chemical name!

Zeneca

AMBUSH® 25W

INSECTICIDE
WETTABLE POWDER *Note: The label is the law!*

RESTRICTED USE PESTICIDE

Due to Toxicity to Fish and Aquatic Organisms

For retail sale to and use only by Certified Applicators, or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification.

ACTIVE INGREDIENT
Permethrin
(3-Phenoxyphenyl)methyl(±)-*cis, trans*-3-
(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate* 25.0%
INERT INGREDIENTS: 75.0%

You **do not** need to record your answers in your journal

You **do** need to be familiar with insecticide labels.

Insecticide Toxicity

Toxicity is defined as the dose that will kill 50 percent of the test animals it was administered to. The dose is expressed as milligrams of insecticide per kilogram of lab animal body weight.

It is referred to as the **LD_{50}**.

'L' stands for "lethal," 'D' stands for "dose" and '50' refers to the 50% killed by the insecticide.

An oral and a dermal dose is determined, meaning how much of the insecticide must be ingested to kill 50% and how much of it just has to land on the skin to kill 50% of the test population.

Pesticide Classification

Lower LD_{50} = greater toxicity

Pesticide law in the U.S. requires that labels be placed on all products, and must include words like "**Danger-Poison**," "**Warning**," and, "**Caution**" along with the LD_{50} for oral and dermal toxicity.

Danger-Poison is the highest classification an insecticide can receive. This classification has an oral LD_{50} of 50 mg/kg or lower.

50mg/kg ~ 1 teaspoon insecticide = 0.08 ounces per 100 pounds

Note: In this example, the amount of insecticide refers to the active ingredient, not the formulated amount.

Insecticides that fall under this highly toxic category are: parathion and aldicarb.

Pesticide Classification (continued)

Toxicity category	Oral/dermal LD_{50} (mg/kg body weight)	Signal Words (required on label)	Insecticide examples
Highly toxic	<50 oral and/or <200 dermal	Danger-Poison	Parathion, nicotine,
Moderately toxic	50-500 oral and/or 200-2000 dermal	Warning	Rotenone, diazinon
Slightly toxic	500-5000 oral and/or 2000-20000 dermal	Caution	Malathion, carbaryl
Low toxicity	>5000 oral and/or >20,000 dermal	Caution	Permethrin

"**Warning**" category insecticides have an oral LD_{50} between 50-500 mg/kg
~ 1 teaspoon - 2 tablespoons of insecticide

Rotenone, nicotine and diazinon fit in this category. (*Note: Diazinon was removed from the market in 2004).*

"**Caution**" is the slightly toxic and the low toxicity category.
Slightly toxic have an oral LD_{50} between 500-5,000 mg/kg (malathion, carbaryl).

Low toxicity have higher than 5,000 mg/kg (permethrin).

13

Learning Game Placeholder

Learning Game: Sequence

Title: Toxicity Quiz

Quiz Answer

This table ranks the compounds with their corresponding oral LD_{50}s.
(Remember, the higher the LD_{50}, the less toxic it is.)

Compound	Oral LD_{50} (mg/kg)
Nicotine	10
Strychnine	30
Caffeine	250
Carbaryl	700
Aspirin	1100-1500
Malathion	1375
Table Salt	3750

It probably did not alarm you that Strychnine was near the top of the list, but were you surprised to find out that caffeine and nicotine are more toxic than the two insecticides listed?

15

Types of Insecticides

Insecticides are classified as **inorganics**, **botanicals**, **synthetic organics**, **insect growth regulators (IGR's)**, and **microbials**.

- **Inorganics** - usually obtained by mining; do not contain organic compounds (those that contain carbon).
- **Botanicals** - obtained from flowers.
- **Synthetic organics -** man-made.
- **Insect growth regulators** - kill insects by affecting insect growth
- **Microbials** - include fungus, bacteria, and viruses.

Inorganics (4 examples you should know)
Arsenic, soap, boric acid, and **diatomaceous earth**.

Arsenic – chemical element and poison used for centuries.
- Toxic to humans.

16

Inorganics

Soap insecticides - obtained from fatty acids.
- Need to contact the insects while the soap is still wet.
- Affect the nervous system (paralysis).
- Disrupt the waterproof waxy layer on the outside of the insect.

Boric acid - purchasable at any discount or home improvement store.
- Abrades the outer waxy layer and causes death from dehydration.

Diatomaceous earth - commonly used amongst organic gardeners.
- A diatom is a type of algae that can live inside a hardened silicate skeleton.
- The shell is very abrasive and breaks down the waxy layer.
- Works great in dry conditions.
- Commonly used in stored product situations like stored pastas and grains.

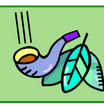
17

Botanicals

Botanicals (5 examples you should know)
Pyrethrum, nicotine, rotenones, and **neem extracts**.

Pyrethrum - obtained from a type of flower similar to the common chrysanthemum.
- Knocks insects down extremely quickly.
- Not very toxic to other animals or humans.
- Commonly used for pests of household pets.
- Short-lived and degrades rapidly.
- When mixed with synergistic compounds, it becomes much more lethal.

Nicotine - derived from the tobacco plant; used since the 1700's.
- Interferes with the nervous system.
- Highly toxic to mammals.
- Crops cannot be harvested for 7 days after it is applied.
- Limited use.



18

Botanicals and Synthetic Organics

Rotenone - obtained from tropical plants; first used to poison fish.
- Used to sanitize a body of water from undesirable fish.
- Also used as a spray or dust for chewing insects in garden and fruit crops.

Neem oil - extracted from tropical neem tree seeds found.
- Breaks down quickly once in the environment.
- Safe for mammals.
- Used as an anti-inflammatory agent and to fight ulcers in humans.
- Marketed under the trade name Azatin®.

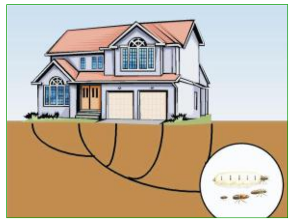
Synthetic organics (5 examples you should know)
Organochlorines, organophosphates, carbamates, pyrethroids, and **chloronicotinyls**.

19

Synthetic Organics

Organochlorines - include Chlordane, Lindane, and DDT.
- Do not break down in the environment very easily.
- Problems with biological amplification.

Chlordane was used up until a few years ago because it can last longer than 20 years in the soil. This is why it was used for termite control around the perimeter of buildings and homes.



Jane Medley, University of Florida

20

Synthetic Organics

Organophosphates – replaced organochlorines.
- Include malathion, diazinon, and Dursban®.

Dursban® was used up until 2004 in the place of chloridane for termite control. Because of environmental concerns, diazinon and Dursban were removed from the market.

These organophosphates range from very dangerous products to ones that are safer to use like Malathion or Lindane.

Carbamates – generally safer to use than organophosphates.
- Toxic to beneficial insects (especially hymenoptera and others things like earthworms.

21

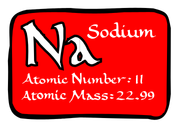
How Organophosphates and Carbamates Work

Organophosphates, carbamates, and nicotine are neurotoxic to their targets and humans.

Acetylcholine (Ach) is released with a nerve impulse and binds to the channels of the next neuron. The open channels allow sodium to enter, and generate nerve stimulus n the next neuron. The impulse continues in this fashion.

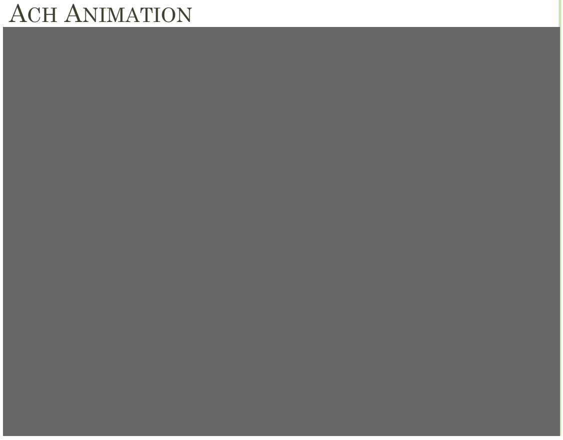
The Ach is then released and broken down by Ach esterase.

Carbamates and organophosphates bind Ach esterase, and prevent the degradation of the nerve impulse. The continuous nerve impulse amplified over the entire nervous system will eventually kill the organism.



22

Ach Animation



Synthetic Organics (Continued)

Pyrethroids are a synthetic version of another chemical we discussed previously.

Which pesticide name does "pyrethroid" sound like?
(pyrethrum)

Common pyrethroids are the pyrethrins which are up and coming products because they are safe for animals and effectively kill insects.

Chloronicotinyls - derived from nicotine.
- Imidacloprid is the only product amongst this class.
- Insects have not developed a resistance to it, yet.
- Imidacloprid is relatively non-toxic to mammals.
- Selective for pest insects.

24

Insect Growth Regulators (IGR's)

Insect Growth Regulators
IGR's - relatively new chemicals that show a lot of promise.

- Specific to insects.
- Juvenile hormone mimics perpetuate molting, preventing adult hood.
- Another kind of IGR is the chitin synthesis inhibitor.
- The insect is not able to form a proper exoskeleton.
- This is extremely safe because humans do not make chitin or juvenile hormone.

Zoecon Gentrol IGR

25

Microbials

Microbials
Bacillus thuringiensis (Bt), **fungi, viruses** and **nematodes**. Most microbials can be applied much in the same way as chemical insecticides (dusts, sprays, baits, etc.)

Bt - common product among organic gardeners to control lepidopteran pests.

Fungal insecticides - used as pesticides since the late 1800's.

- Needs humidity and a certain temperature to germinate.
- Fungi are not widely used as insecticides.


USDA - Fire ant queen with *Metarhizium anisopliae* fungus

26

Microbials (Continued)

Viruses - are produced commercially to control some caterpillars.

- Expensive
- Only infect the target arthropods.

Nematodes - microscopic worm that lives in the soil.

- Some feed parasitically on insects.
- Mass-produced and applied as an insecticide.
- Can be added to water and sprayed on turf.
- Enter through an insect's mouth or spiracle and release bacteria into the insect. Require high moisture to survive.
- Sensitive to solarization (heat death from sun exposure).

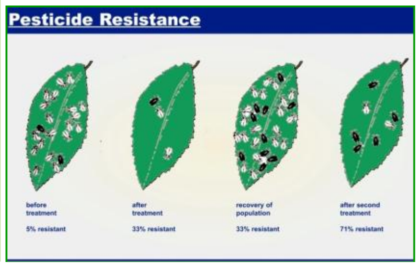
Female nematodes

Nematodes crawling out of a mole cricket they have just killed.

27

Pesticide Resistance

- Before treatment, 5% of the insects on the leaf are resistant.
- After the leaf is treated, the resistant insects survive.
- The ones left on the leaf reproduce; the resistant percentage increases to 33%.
- You treat again and wipe out most of the non-resistant insects; this will increase your defiant population to 71% of the entire population!



Modified from Daly *et al*. 1998, p287

28

Insecticide Disadvantages

- Can injure or kill humans when misused.
- Wildlife and beneficial insects are often negatively impacted.
- Can end up in rivers and streams, killing fish and aquatic plants.
- Some build up in the soil (chlordane; DDT).
- Pest resurgence, secondary pest outbreaks, pesticide resistance.

29

Insecticide Advantages

- Act quickly
  - Farmer can cure an insect problem before the crop is lost.
  - Fire ants can be managed before children are stung.
- Variety of insecticidal options that suit your needs.
- Easy to apply as long as the label directions are followed.
- Relatively inexpensive to use.
- Reduce insect populations that spread diseases.

30

Learning Game Placeholder

Learning Game: Choices

Title: Review Quiz

Conclusion

Do you understand pesticide labeling?

Do you know some modes of action of certain insecticides?

What is tolerance?

When can a farmer treat a field?

Make sure that you are familiar with these topics and please review your lesson objectives before moving on to unit 14.

32