Biological Control: The Basics

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Biological Control

What is it ?

Why use it?

When does it work?

Where does it work best?

Types of Biological Control?

Some types of Biocontrol agents

Biological Control

What is it?

(Broad definition)
The use of living organisms to control pest species.

includes organism bi-products E.g. hormones, toxins, genes, antagonists or other products from dead or live animals)
referred to as Biorational agents

(Strict definition)
A biological control agent must be living so that it is self-sustaining and responds to pest populations in a density-dependent manner.

Why use Biological Control?

Reduction of chemical pesticide usage

probably the most important reason

Chemical pesticides are often **broad spectrum**.

Biologicals are frequently quite **host specific** and there are many **diverse types**

E.g live agents, bi-products, antagonists etc.

Chemical pesticides are valuable and expensive to develop

- **over use them = lose them** - resistance
- environmental toxicity
- become less effective - pesticide treadmill.

Pesticide treadmill - kill both pests and predators → larger pest resurgence and 2° pests emerge → further larger & more frequent pesticide applications

Limitations of Biological Control

BC is not appropriate in all situations
Two such situations are

Immediate Solutions **BC is a slow and permanent process and not a quick fix.**
If emergency conditions arise e.g. serious pest or disease outbreaks pesticides must be used.
If economic loss is to be prevented.

Pest Eradication **BC is not appropriate is when total pest eradication is required. E.g disease vectoring species outbreak after a natural disaster**

As its name suggests BC is a **control** as it relies on natural processes which work to maintain a balanced compromise between species and not eradication of a species.

Which Habitat Type is Best?

Stable undisturbed ecosystems - Parks and Forests

Long term agroecosystems - orchards and forests,

Poor in frequently disturbed systems

e.g. seasonal crops

Best in crops with a high economic damage threshold

Isolated Ecosystems

Relatively geographically isolated areas

e.g. California agricultural regions

Islands e.g. Australia, Hawaii.

Types of Biological Control

- Classical
- Augmentation
- Conservation

Classical Biological Control (CBC)

The importation and permanent establishment of a foreign natural enemy (NE) to control an exotic invasive pest

Theoretical Basis for CBC

Enemy Release Hypothesis

In their native habitat most species are not pests as they are kept in balance by the presence of NE.

After being introduced into a foreign habitat without NE and other natural controls they spread uninhibited, becoming pests.

Goal of CBC

to restore some degree of natural balance found in the pests native habitat by introducing and permanently establishing a NE from the pests native habitat.

Classical Biological Control Agents

Predators and **parasitoids** are mostly used to control insect pests and weeds

Pathogens i.e. fungi, bacteria and viruses are used much less primarily b/c the regulations controlling the introduction of exotic pathogens are very stringent.

Host Specificity: NEs that are host specific are carefully chosen so that non-target organisms are not accidentally impacted.

Best target hosts: Stationary specialists that aggregate on exposed surfaces
OR slow moving defenseless life stages

Most difficult to control pests live in **cryptic habitats**

Successful Types of Natural Enemies

The attributes of a predators and parasitoids that make successful CBC natural enemies are:

1) narrow host range leading to a density-dependent relationship with the host.

2) good searching strategies (ability to quickly form a search image).

3) high fecundity lots of offspring

4) high adaptability to introduced environment.

5) lack of predators and hyperparasitoids

Augmentation Biological Control (ABC)

"adding to" or helping of Natural enemies (NE) already present in an area.

ABC is used when

1) NE are completely absent
2) naturally occurring NE control occurs too late
3) naturally occurring NE control is insufficient

Most common form of BC practiced as it relies on the use of commercial products.

Fits the chemical pesticide idea of control – "buy and apply"

Augmentation is the least sustainable form of BC as it requires the regular or periodic purchased inputs.

Two general approaches to ABC:
inundative releases and inoculative releases.

Inundative Release

the mass release of large numbers of natural enemies for immediate pest reduction.

Corrective measure - used after the pest outbreak has occurred

No reproduction or establishment of NE is expected

Control is short term. the NE is released into habitats where it is not expected to survive

Inoculative Release

Smaller numbers of NE are released at prescribed intervals throughout the pest period, starting when the pest population is very low.

The NE are expected to reproduce and provide longer-term control in a density dependent manner. but not establish permanently.

The expected outcome of inoculative releases is to keep the pest at low numbers, never allowing it to approach an economic injury level;

therefore, it is more of a preventive measure.

Conservation Biological Control

“Modification of the environment or existing practices to protect and enhance specific NE or other organisms to reduce the effect of pests”

Developed originally to rescue NE from the ravages of chemical pesticide over use.

i.e. stop the pesticide treadmill.

Eventually methods to enhance NE existence were developed.

More appropriate for crops with high damage thresholds and
not high value crops which can withstand little damage

Conservation BC can be broken down into two major parts

Conservation:

Altering pesticide application and land use strategies so that natural enemies can survive.

- Selective insecticides i.e. *Bti*
- Specific formulation & application locations
- Timed Applications
- Nonpersistent pesticides

- Reduce tillage strategies

Enhancement:

Providing food resources i.e. nectar and pollen

Providing permanent habitats, shelter and favorable microclimates

Providing alternative prey or hosts

Shelterbelt

Grass margin along a hedge row

Increased habitat diversity = more NE = pest control

Diverse habitats i.e. field borders with flowering plants provide pollen, nectar, alternate hosts and refuges from which NE can migrate into agricultural monocultures.

Biological Control Agents for Mosquitoes

Many true BC agents have been tested but to date have not generally proven to be operationally feasible.

Fish are the most widely used and successful true BC agents.

Some others include:

Aquatic insect adults and larvae
Fungi *Laegenidium giganteum*
Mermithid nematodes i.e. *Romanomermis*
Predaceous mosquito *Toxorhynchites*,

Two groups: those that target adults and
those that target larval & egg stages

Fish

the most extensively used biocontrol agent for mosquito control. *Gambusia affinis* and other top minnows (*Poeciliidae*) and killifish (*Cyprinodontidae*) are collected or reared for release and placed in permanent or semipermanent water bodies for larval control

killifish (2 of ~1270 species)
Some spp live only 2 months
good for temporary control

New *Gambusia* introductions not encouraged

- Reduced ~30 native fish spp. and invertebrate fauna.
- Eat zooplankton resulting in algal blooms

Fungi/ Protozoan

Lagenidium giganteum **is a freshwater watermold specific to larval mosquito. Infected larvae appear white.**

Facultative parasite, grows vegetatively on debris without a host. Dried resting stages remain viable dried ~ 7 years.

Can **recycle for weeks to years after a single application.**

Mass produced and is commercially available for mosquito control.

Several other fungi are commercialized for mosquito control. E.g. *Coelomomyces* and *Culicinomyces.*

Aquatic Insect Predators

Various adult and larval stages of several insect orders predate mosquito larvae i.e. beetles, aquatic bugs, dragonflies,
Invade temporary pools and puddles

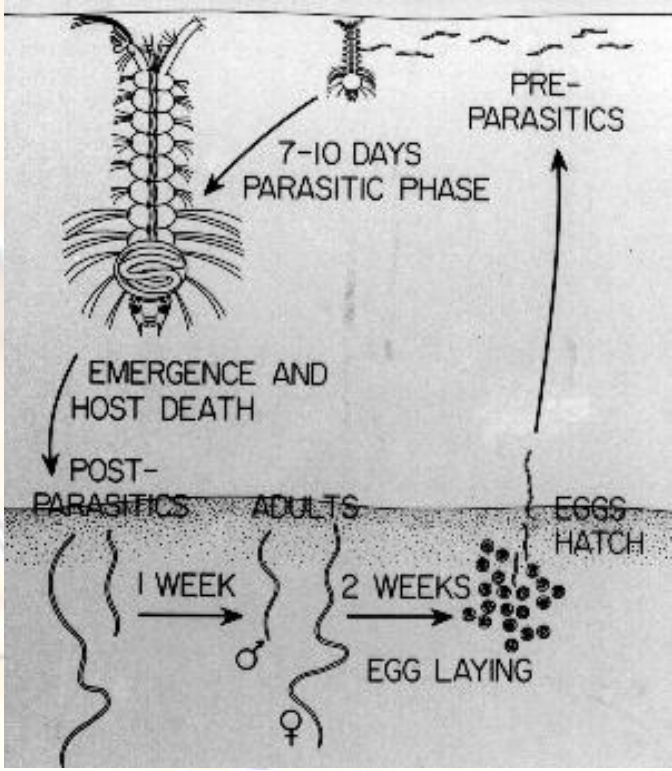
Mermithid Nematodes

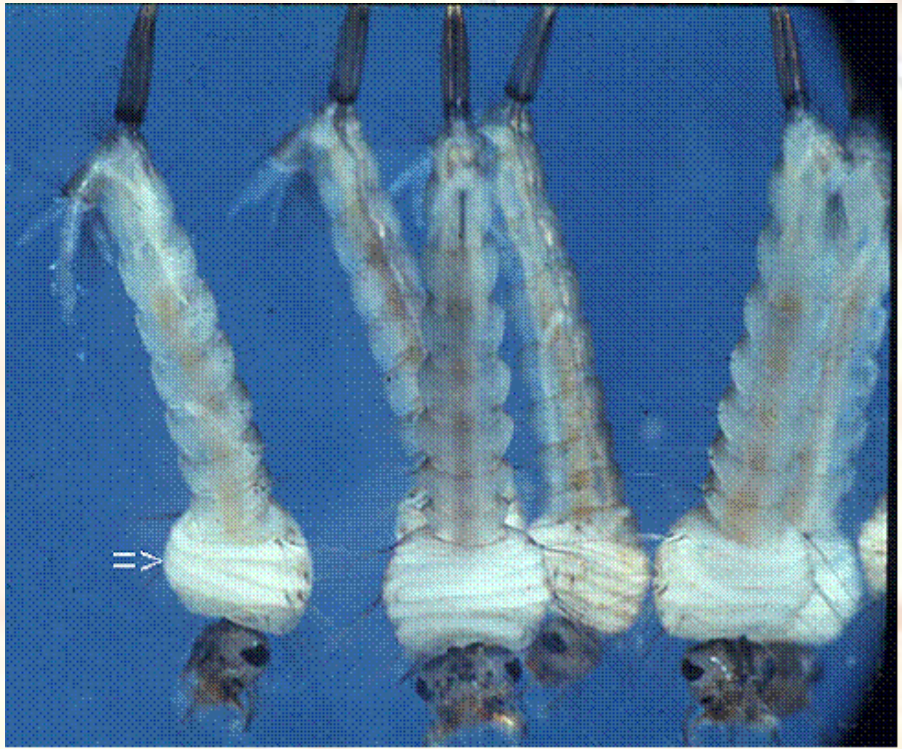
Infect many arthropods most are very host specific.

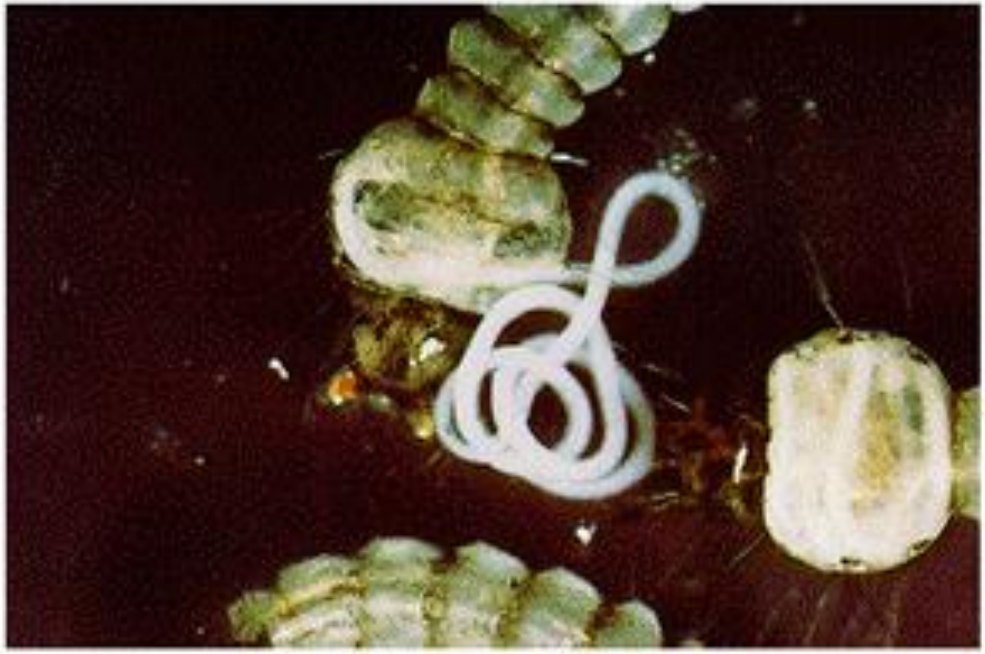
Effective in clean shallow pools

Very hard to mass produce

Romanomermis culicivorax once commericalised as “Skeeter doom in late 1980s







Toxorhynchites sp.

- Breed in natural cavities and artificial containers.
- Large predatory larva of other mosquito larva and similar sized nekton.
- Prone to cannibalism and exhibit killing sprees prior to pupation
- Non blood feeding autogenous adults.
- Difficult to rear in large numbers

Summary Biological Control

Many agents tested, few are very effective and even fewer commercially viable.

most successful BC are Biorational pesticides

- products of organisms

e.g.Bacterial toxins and insect growth regulators

Work best in combinations of several BC agents, and when used in integrated pest management strategies (IPM)

Work best in stable undisturbed environments as preventative or suppressive measures.

No good for eradication or emergency measures.

Improved formulation technology and application strategies needed for many.