



**Pest Control and Natural Conservation**

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## Today's topics

- Integrated pest management
  - The brown planthopper in Indonesia
- Biological control
  - A scale insect in USA
- The problems of biological control
  - Asian ladybird beetle in USA and Europe

## Why insects become pests?

- Some previously harmless insects become pests after their accidental (or international) introduction to areas outside their native range, where they escape from the controlling influence of their natural enemies.
- An insect may be harmless until it becomes a vector of a plant or animal pathogen.
- Native insect may become pests if they move from native plants onto introduced ones.
- The simplified, virtual monocultural, ecosystems in which our food crops, forest trees and our livestock are grown create dense aggregations of predictably available resources that encourage the proliferation of specialist and some generalist insects.

(Gullan & Cranston 2000)

## The idea of integrated pest management (IPM) arose against the unthinking use of chemical pesticides in the 1940s and 1950s.

(Begon, Harper, & Townsend 1996)

## Integrated pest management (IPM)

Integrated Pest Management (IPM) is a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economic injury.

(FAO 1975)

## The aims of IPM

- To understand thoroughly the interactions of organisms and their environment in those systems, such as a pasture, cultivated field, or orchard
- To determine the level, or threshold, of economic injury that will necessitate control measures
- To develop a program or series of treatments that will not upset other highly desirable interactions between other organisms of the ecosystems

## The methods of IPM

- Chemical control; insecticide
- Biological control; natural enemies
- Host-plant resistance
- The use of attractants; pheromones
- Genetic control

## The merits and demerits of insecticides

### Merits

- Effectiveness, especially quick-activity
- Low price

### Demerits

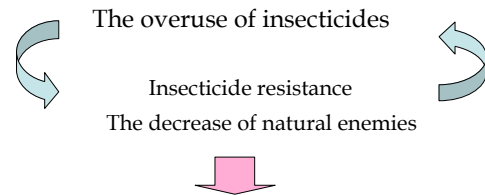
- Insecticide resistance
- Destruction non-target organisms, e.g. natural enemies
- Adverse environmental effects
- Danger to human health

Pest resurgence & secondary pest outbreak

## The overuse of insecticide

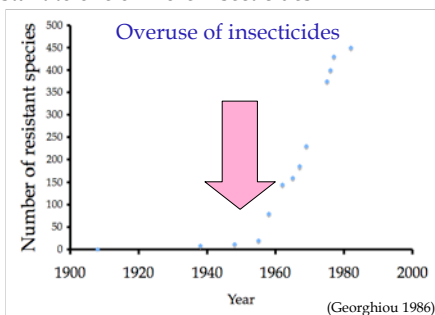
- The occurrence of insecticide resistance, which is the result of the selection of individuals that are predisposed genetically to survive an insecticide.
- The decrease of natural enemies at the environment.

## The vicious cycle of insecticide overuse



The artificial selection, *i.e.*, overuse of insecticides, destroys the complexity of the agricultural ecosystems, resulting in the occurrence of more/strong insect pests

Cumulative increase in the number of arthropod species (mostly insects and mites) known to be resistant to one or more insecticides



This vicious cycle of insecticide overuse brings large benefits only for chemical industries, not for farmers and agricultural environments, including crops and insect communities.

## The methods of IPM

- Chemical control
- Biological control
- Host-plant resistance
- The use of attractants
- Genetic control

## In Asian countries

- Most serious pest of rice is the brown plant hopper, *Nilaparvata lugens*, which sucks plant sap causing the leaves to go brown and die ('hopperbrown').



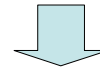
(Gullan & Cranston 2000)

## In Indonesia

The rise to pest status of the brown planthopper coincided with 1) the widespread cultivation of modern, high-yielding rice varieties, 2) the concomitant increased use of nitrogenous fertilizers, and 3) the overuse of insecticides.

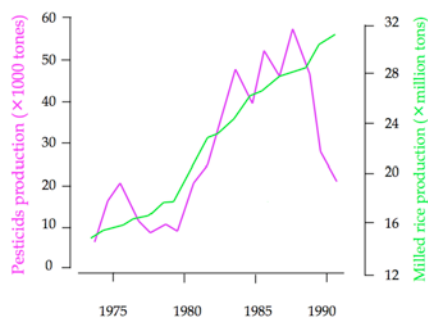
## IMP for rice in Indonesia

- Biological control (parasitoids & predators)
- Use of resistance rice
- Reduction the use of insecticide
- Education for farmers

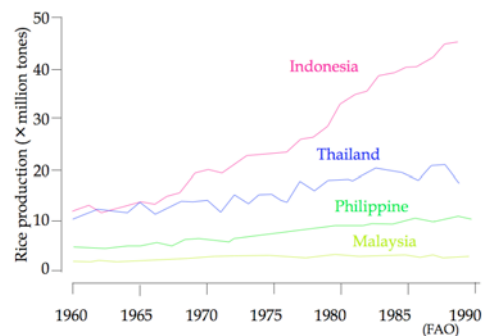


- Insecticide use has gone down (c. 60%)
- Rice production has gone up (c. 13%)

## Pesticide usage and rice production in Indonesia



## Rice production in South-East Asia



## The components of IPM

- Chemical control
- **Biological control**
- Host-plant resistance
- The use of attractants
- Genetic control

## Biological control

- The term 'biological control' was introduced by Smith (1919) to describe the use of natural enemies to control insect pest.

## Biological control

The regulation of the abundance and distributions of pest by using the activity of naturally-occurring enemies, namely predators, parasites/parasitoids, pathogens and/or competitors.

## The advantages of biological control

- Host specificity
  - Usually, the natural enemies only decrease the population level only for the target species.
- Low cost
  - Once the predators/parasitoids are established, the natural enemies reproduce by themselves.
- Less impacts on the environments

## Ladybirds as biological agents

- Coccinellids, *i.e.*, ladybird beetles, have been widely used in biological control for over a century because coccinellids important natural enemies of pest species, especially, whitefly, aphids, mealybugs, scales, and mites (Obrycki & Kring 1998).



Gullan & Cranston 2000)

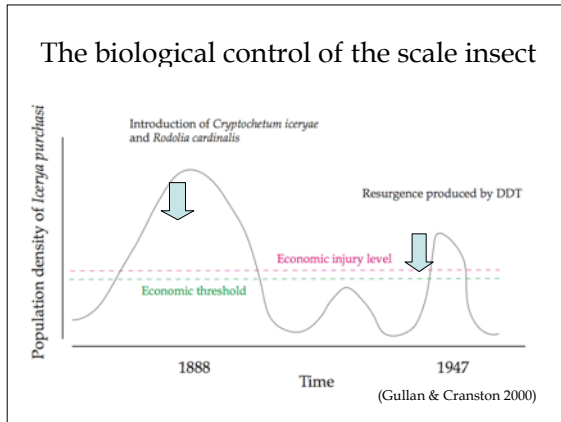


UC Statewide IPM Program  
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Charis Darwin Foundation News

- The first great success was obtained in 1889 with the introduction of an Australian ladybird (*Rodolia cardinalis*) into California to control a scale insect (*Icerya purchasi*), which was devastating the Californian citrus industry.

## The biological control of the scale insect



The decline in the abundance of the mealybug *Icerya purchasi* following the release of *Rodolia limbata* on an atoll in the Federated State of Micronesia

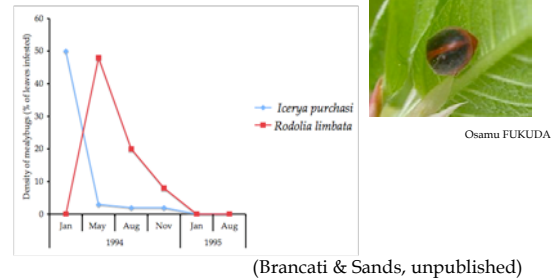


Table 1 Attributes of biological control agents indicated by empirical and theoretical studies

### Empirical

- Ecological capability
- Temporal synchronization
- Density responsiveness
- Reproductive potential
- Searching capacity
- Dispersal capacity
- Host/prey specificity and compatibility
- Food requirements
- Habitat requirements
- Natural enemy

### Theoretical

- Synchrony or slight asynchrony
- High relative rate of increase
- High searching efficiency
- Interference amongst the natural enemy
- Aggregation on host patches
- Dispersal ability

## Failure of biological control -A case study of *Harmonia axyridis*-

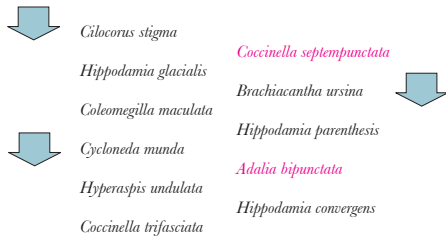
- The indiscriminant use of pesticides that occurred 1950 - 1960 has been replaced with ecological pest management systems, especially in USA (National Research Council 1996). Typically, beneficial organisms from different parts of the world are imported into the United States, evaluated for biological control, and established in areas afflicted by pest outbreaks (Van den Bosch et al. 1982).

- Some of the introduced biological agents have successfully regulated pest populations (Caltagirone 1981; Haynes & Gage 1981). In recent years, however, exotic species can attack non-target organisms, or compete with and eventually displace native beneficial fauna (Wheeler & Hoebeke 1995; Elliot et al. 1996).



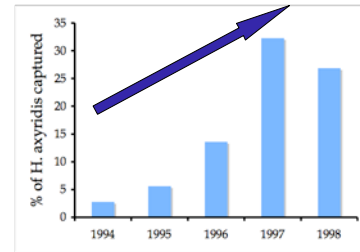
- The multicolored Asian ladybird beetle, *Harmonia axyridis*, originated in northeast parts of Asia, was introduced several times into USA, more recently into European countries, mainly for biological control for aphids. However, this species is having a large impact on endemic ladybird species in USA and European countries.

The effects of *H. axyridis* invasion to endemic and exotic species at Michigan, USA



(Coluna-Garcia & Gage 1998)

% *H. axyridis* captured in total at Michigan, USA



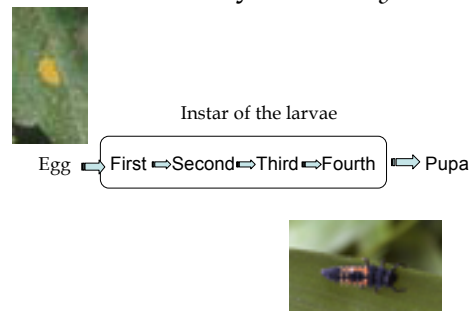
(Colunga-Garcia & Gage 1998)

Why *H. axyridis* gives large impacts on ladybird communities at foreign countries ?

Characteristics in life history in Japan

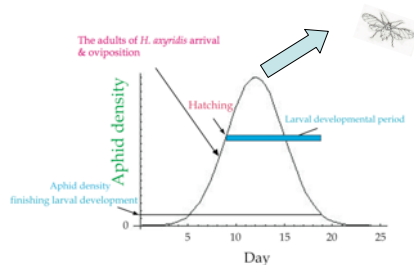
- *H. axyridis* vs. aphid population level interaction
- Aggressiveness: cannibalism and intra-guild predation
- Habitat utilize patterns

Life history of *H. axyridis*



<http://www.insects.jp/kon-tentounami.htm>

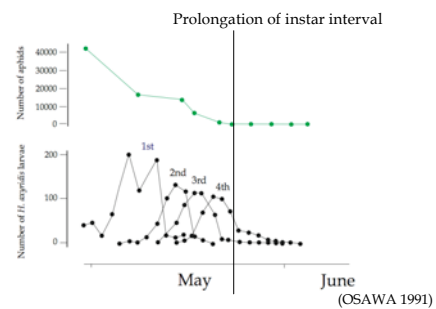
The schematic model for timing of *H. axyridis* arrival and population dynamics of the prey aphids



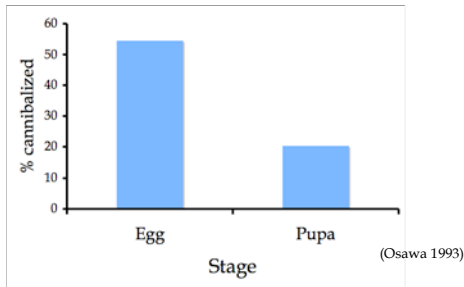
When the larvae of *H. axyridis* finish their development, prey density is too scarce for their development

Dixon AFG (1998) Aphid Ecology, Chapman & Hall, London

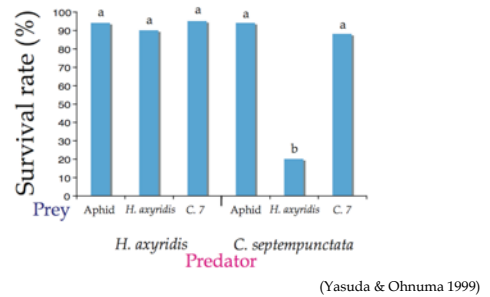
Population dynamics *H. axyridis* larvae and prey aphid



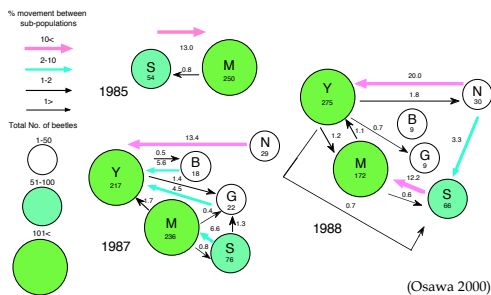
### Cannibalism in *H. axyridis*



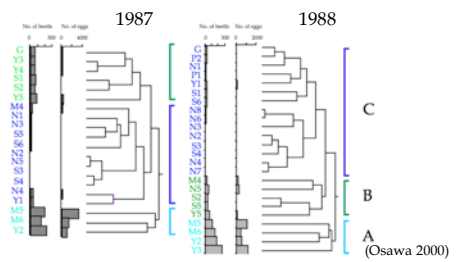
### Intra-guild predation *H. axyridis* vs. *C. septempunctata*



### Movement patterns of *H. axyridis* adult



### Habitat clustering in *H. axyridis*



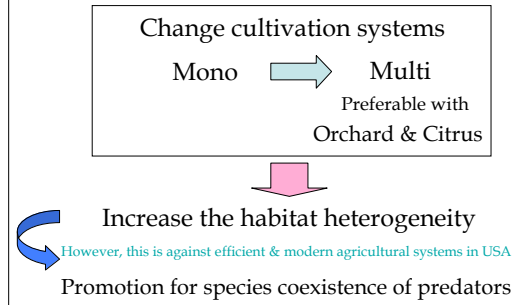
- Analysis of *H. axyridis* vs. aphid population level interaction
  - *H. axyridis* and aphid population are not synchronized, resulting severe food shortage at *H. axyridis* larvae.
  - ↓
  - This implies that *H. axyridis* is not a suitable agent for biological control to make aphid densities at low level.
- Analysis of aggressiveness: cannibalism and intra-guild predation
  - *H. axyridis* is very aggressive.
  - ↓
  - This may cause *H. axyridis* gives large impacts on endemic predators at foreign countries.

- Analysis of habitat utilize patterns
  - *H. axyridis* utilizes heterogenous habitats, resulting the species coexistence of predators in Japan.
  - ↓
  - Uniform and continuous agricultural environment may give a strong selection pressure favored by an aggressive predators like *H. axyridis*.

Table 1 Attributes of biological control agents indicated by empirical and theoretical studies

Empirical	Theoretical
<ul style="list-style-type: none"> <li>• Ecological capability</li> <li>• Temporal synchronization</li> <li>• Density responsiveness</li> <li>• Reproductive potential</li> <li>• Searching capacity</li> <li>• Dispersal capacity</li> <li>• Host/prey specificity and compatibility</li> <li>• Food requirements</li> <li>• <i>Habitat requirements</i></li> <li>• Natural enemy</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Synchrony or slight asynchrony</i></li> <li>• High relative rate of increase</li> <li>• High searching efficiency</li> <li>• <i>Interference amongst the natural enemy</i></li> <li>• Aggregation on host patches</li> <li>• Dispersal ability</li> </ul>

To reduce the *H. axyridis* impacts on endemic predator communities



◆ Before introducing exotic predators for biological control, we should more precisely check empirical and theoretical attributes of target species for pest control and natural conservation.



## **Selected References for further understanding**

### Papers

Colunga-Garcia M & Gage S H (1998) Arrival, establishment, and habitat use of the multicolored Asian lady beetle (Coleoptera: Coccinellidae) in a Michigan landscape. *Environmental Entomology* 27: 1574-1580.

Kogan K (1998) Integrated pest management: historical perspectives and contemporary developments. *Annual Review of Entomology* 43: 243-270.

### Books

Begon M, Harper J L, Townsend C R (1996) *Ecology, third edition*. Blackwell Science, Oxford, UK .

Dixon A F G (2000) *Insect Predator-Prey Dynamics Ladybird Beetles & Biological Control*. Cambridge University Press, Cambridge, UK.

Gullan P J & Cranston P S (2000) *The Insects An Outline of Entomology*. Blackwell Science, Oxofrd, UK.

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