BIOLOGICAL CONTROL - DEFINITION – HISTORY - CLASSICAL EXAMPLES - FACTORS GOVERNING BIOLOGICAL CONTROL

Definition

H. S. Smith (1919)- First used term "biological control" to signify the use of natural enemies (whether introduced or otherwise manipulated) to control insect pests.

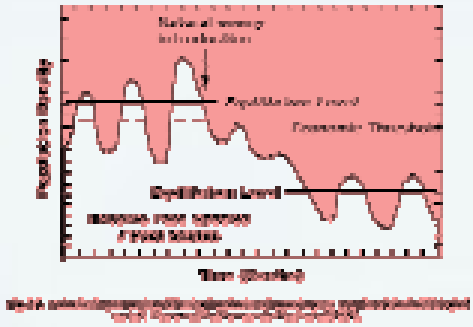
B. P. DeBach (1964) -Further refined the term and distinguished "natural control" from "biological control":

Natural control is "the maintenance of a more or less fluctuating population density of an organism within certain definable upper and lower limits over a period of time by the actions of abiotic and/or biotic environmental factors" .

Why biological control.....

- Highly economical
- Selective with no side effects
- Self propagating and self-perpetuating
- Pest resistance to BCAs is virtually unknown
- No harmful effects on humans, livestock's and other organisms
- Virtually permanent
- Efficiency, greater ability to search their prey
- Improved quality of produce
- Compatible with most of the IPM components

Biological control is "the action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average than would occur in their absence".



Van den Bosch *et al.* (1982) -modified the terms somewhat and referred to:

- **Applied biological control** as the "manipulation of natural enemies by man to control pests"
- **Natural biological control** as that "control that occurs without man's intervention"

History and development of biological control and classical examples of biological Control

I. Early History

A. 200 AD to 1200 AD : BC agents were used in augmentation

900 AD- First use of red ant, *Oecophylla smaragidna* to control leaf chewing insects on mandarin trees

1200 AD-Ants were used for control of date palm pests in Yemen (south of Saudia Arabia).

-Usefulness of ladybird beetles recognized in control of aphids and scales

B. 1300 A.D. to 1799 A.D. : BC was just beginning to be recognized

1602 - Aldrovandi noted the hymenopteran parasite, *Apanteles glomeratus* laying eggs in the pupae of the cabbage butterfly, *Pieris brassicae*

1726- The first insect pathogen was recognized by de Reaumur. It was a *Cordyceps* fungus on a noctuid

1762 - Indian mynah bird, *Gracula religiosa* exported from India to Mauritius to control red locust, *Nomadacris septemfasciata*

1776- Control of the bedbug, *Cimex lectularius,* was successfully accomplished by release of the predatory pentatomid ,*Picromerus bidens* in Europe

C. **1800 A.D. to 1849 A.D. :** During this period advances were made in Europe which were both applied and basic

II. The Intermediate Period: 1888 to 1955

A. 1888- Vadalia beetle, *Rodolia cardinalis* was brought from Australia and introduced into California (Control) cottony cushion scale, *Icerya purchasi* on citrus

It's a first well planned and successful classical biological control attempt made

Overview of The Cottony Cushion Scale Project

- In 1868 Cottony cushion scale, *Icerya purchasi Maskell,* was introduced into California in ca. around the Menlo Park (CA) area (near San Francisco) by 1887 it spread to southern California.
- C. V. Riley (Chief of the Division of Entomology, USDA) employed Albert Koebele and D. W. Coquillett in research on control of the cottony cushion scale and found no methods to control.
- In1888 Koebele was sent to Australia to collect natural enemies of the scale,He sent ca. 12,000 individuals of *Cryptochaetum iceryae and 129* individuals of *Rodolia cardinalis (the vedalia beetle)*

1898- Austalian *Cryptlaemus montrouzieri* in India on *Coccus viridis*

B. 1900 to 1930: New faces and more BC projects

1902- The *Lantana Weed Project in Hawaii* (1902) First published work on BC of weeds.

1911- Berliner described *Bacillus thuringiensis as causative agent of* bacterial disease of the Mediterranean flour moth

1919- USDA laboratory for biological control established in France .

1927- The Imperial Bureau of Entomology created the Farnham House Laboratory for BC work in England .

C. 1930 to 1955: Expansion and decline of BC

- 1930 to 1940- Peak in BC activity in the world (57 different natural enemies established)
- World War II caused a sharp drop in BC activity with switch to pesticide research
- 1920 - A parasitoid *Aphelinus mali introduced from England into India to control* Woolly aphid on Apple, *Eriosoma lanigerum*.
- 1929-31 - *Rodolia cardinalis imported into India (from USA) to control cottony* cushion scale *Icerya purchasi on Wattle trees.*
- 1947- The Commonwealth Bureau of Biological Control (CBBC) was established
- 1951- CBBC renamed as Commonwealth Institute for Biological Control (CIBC). Headquarters are currently in Trinidad, West Indies.
- 1955- The Commission Internationale de Lutte Biologique contre les Enemis des Cultures(CILB) was established.
- 1962- The CILB changed its name to the Organisation Internationale de Lutte Biologique contre les Animaux et les Plants Nuisibles.

  Also known as the **International Organization for Biological Control (IOBC).**

III. The Modern Period: 1957 to Present

1958-60 - Parasitoid *Prospatella perniciosus imported from China*

1960 - Parasitoid *Aphytis diaspidis imported from USA*

Both parasitoids used to control Apple Sanjose scale *Quadraspidiotus perniciosus*

1964 - Egg parasitoid *Telenomus sp. imported from New Guinea to control Castor* semilooper *Achaea janata*

1964- Paul DeBach and Evert I. Schliner (Division of Biological Control, University of California, Riverside) published an edited volume titled "Biological Control of Insect Pests and Weeds"

1965 - Predator *Platymeris laevicollis* introduced from Zanzibar to control coconut Rhinoceros beetle, *Oryctes rhinoceros*

Three approaches to biological contr ol

1. **CONSERVATION OF NATURAL ENEMIES:** Actions that preserve and increase NE by environmental manipulation. e.g. Use of selective insecticides, provide alternate host and refugia for NE.
2. **CLASSICAL BIOLOGICAL CONTROL:** The control of a pest species by introduced natural enemies (Mainly to control the introduced pest)
3. **AUGMENTATION OF NATURAL ENEMIES:** Propagation (mass culturing) and release of NE to increase its population. Two types,

   (i) **Inoculative release:** Control expected from the progeny and subsequent generations only.

   (ii) **Inundative release:** NE mass cultured and released to suppress pest directly e.g. *Trichogramma* sp. egg parasitoid, *Chrysoperla carnia* predator

Classical biological contr ol achieved in India

- 1795- Cochineal insect, *Dactylopius ceylonicus* was introduced from Brazil against carmine dye producing insect, *D. coccus*.
- 1983-1984- Exotic weevil, *C. Salviniae* from Australia against water fern, *Salvinia molesta* in a lily pond in Bangalore.
- 1982- Three exotic natural enemies were introduced *viz*., hydrophilic weevils – *Neochetina bruchi* (Ex. Argentina) and *N. eichhorniae* (Ex. Argentina) and galumnid mite *Orthogalumna terebrantis* (Ex. Sout h America) against water hyacinth.
- 1926- The coccinellid beetle, *Rodolia cardinalis* against cottony cushion scale, *I. purchasi*

- 1983- The encyrtid parasitoid *Leptomastix dactylopii* against *Planococcus citri* and *P. lilacinus* from Trinidad, West Indies
- 1983- A chrysomelid beetle *Zygogramma bicolorata* against parthenium from Mexico
- 1988- The coccinellid predator, *Curinus coeruleus* against *H. cubana* from Thailand
- 1921- the agromyzid seedfly, *Ophiomyia lantanae* against *Lantana camara* from Hawaii (origin: Mexico) and released in south India
- 1941- Tingid lace bug, *Teleonemia scrupulosa*, against *L. camara* from Australia
- 1951- *C. Montrouzieri* against mealybugs
- 1963-The gallfly, *Procecidochares utilis* against Crofton Weed, *Ageratina adenophora* from New Zealand to Nilgiris (Tamil Nadu), Darjeeling and Kalimpong areas (West Bengal)
- 2010-Three exotic encyrtid parasitoids viz., *Acerophagus papayae, Anagyrus loecki* and *Pseudleptomastix mexicana*, against papaya mealybug, *Paracoccus marginatus*

Steps in Classic Biological Control

1. Evaluate the pest problem
2. Foreign exploration
3. Selection
4. Quarantine processing
5. Mass propagation
6. Field colonization (release)
7. Evaluation of impact

100 successes in the past 100 years!!

Biocontrol agents employed in Biological control programme

A. Predator - An animal that feeds upon other animals (prey) that are either smaller or weaker than itself

Characteristics of Predators

- An immature predator will consume a number of prey in the process of completing development to the adult stage.
- The predator is free living in all life stages except the egg.
- The eggs are usually laid in the vicinity of the prey.
- Upon hatching from the egg, predator nymphs or larvae actively seek out, capture, kill, and consume prey.
- Many predators are carnivorous in both the immature and adult stages (but there are exceptions [e.g., syrphid flies]).

Potential Insect Predators

Order	Family	Species	Hosts
Coleoptera	Coccinellidae	*Cryptolaemus montrouzieri*	Aphids, Scales, Mealybugs, Eggs of lepidopterans
		Rodalia cardinalis	
		Cheilomenes sexmaculata	
		Harmonia octomaculata	
		Chilocoris nigrata	
		Scymnus coccivora	
		Parascymnus horni	
		Coccinella transversalis	


C. montrouzieri


R. cardinalis


C. septempunctata


C. sexmaculata


S. coccivora

Contd...

	Cicindelidae	*Cicindella sexmaculata*	Aphids, Scales, Mealybugs, Eggs of lepidopterans
	Carabidae	*Cosnoidea indica*, *Anthia sexguttata*	Aphids, Scales, Mealybugs, Eggs of lepidopterans
Odonata		Dragon fly and damsel flies	Caterpillars
Mantodea		*Mantis religiosa*	Caterpillars and Grasshoppers


Dragon fly


Mantis religiosa


Anthia sexguttata


Asilus sp.


Ischiodon scutellaris

Contd...

Order	Family	Species	Hosts
Neuroptera	Chrysopidae	*Chrysoperla zastrowi arabica*	Aphids, Scales, Mealybugs, Eggs of lepidopterans
	Hemerobiidae	*Micromus igoratus*	
Hemiptera	Miridae	*Cyrtorrhinus lividipennis*	Hemipterans
	Ruduviidae	*Platymeris laevicollis*	Grubs
	Pentatomidae	*Eucanthecona furcelleta*	Caterpillars
Lepidoptera	Epipyropidae	*Dipha aphidivora*	Aphids
Diptera	Asilidae	*Asilus* sp	Small insects
	Syrphidae	*Ischiodon scutellaris*	Small insects

C. zastrowi arabica

C. lividipennis

Dipha aphidivora

Micromus igoratus

Field applications.....

Species	Host/s	quantity
Cryptolaemus montrouzieri	mealybugs	3000-4000/ha
Rodalia cardinalis	Aphids/scales/mealy bugs	3000-4000/ha
Chilocoris nigrata	Aphids/scales/mealy bugs	3000-4000/ha 10-12/plant
Chrysoperla zastrowi arabica	Aphids/scales/mealy bugs/ Eggs of lepidopterans	1.00-1.50 lakh/ha
Micromus igoratus	Aphids	5000-6000 /ha
Cyrtorrhinus lividipennis	Hemipterans	50-60 bugs/100m^2
Dipha aphidivora	Aphids	5000-6000 /ha

B. Parasitoid: It is a special kind of parasite which often about the same size as its host, kills its host and requires only one host (prey) for development into a free-living adult.

Characteristics of insect parasitoids:

- Host searching capacity
- Host specificity
- Universal adoptability
- Dispersal ability
- Amenability to mass culture
- Ability to withstand competition
- Ability to out number the pest
- Survival capacity

Predator V/S **Parasitoids**

Predators	Parasitoids
1. Bigger than the prey	1. Smaller than its host
2. Very active	2. Usually sluggish once the host in secured
3. Organ of locomotives, sense organ and mouth parts are well developed.	3. Organ of locomotives, sense organ and mouth parts not well developed
4. Habitat is independent of its prey.	4. Habitat in same that of its host.
5. Life cycle in longer than the host.	5. Life cycle shorter than the host
6. A single predator may attack several host in in its life period	6. It usually completes development in a single host.

Types of parasitoids

1. **Based on the developmental site in the host**

   a. Ectoparasitoid : An insect parasite which develops externally on its arthropod host.

   (eg). *Bracon brevicornis* on coconut black headed caterpillars.

   b. Endoparasitoid : An insect parasitoid which develops within the body of its arthropod host. (eg) *Eriborius trochanteratus* on coconut black headed caterpillar.

B. brevicornis* on larva of *Opisina arenosella

2. Based on the stages of the host attacked

Order: Hymenoptera (90% of parasitoid coming under this order)

Stage	Family	Species	Hosts
Egg parasitoid	Trichogrammatidae	*Trichogramma chilonis*	Eggs of sugarcane internode borer, cotton bollworm, rice leaf folder
		T. japonicum	Eggs of rice stem borer
	Scelonidae	*Telenomus rowani*	Eggs or rice stem borer
		Telenomus remus	Eggs of tobacco caterpillar

Trichogramma sp.

Telenomus remus

Contd…..

Stage	Family	Species	Hosts
Egg-larval parasitoid	Braconidae	*Chelonus blackburni*	Eggs of cotton spotted bollworm
	Encyrtidae	*Copidosoma koehleri*	Potato tuber moth

Chelonus blackburni

Copidosoma koehleri parasitizing eggs and larvae of PTM

Contd…..

Stage	Family	Species	Hosts
Larval parasitoid	Bethylidae	*Goniozus nephantidis*	Late larval CBHC
	Platygastridae	*Platygastor oryzae*	Larvae of rice gall midge
	Ichneumonidae	*Campoletis chloridae*	Larval Spodoptera or Helicoverpa
		Erioborus trochanteratus	Larval CBHC

Campoletis chlorideae

Goniozus nephantidis

Platygastor oryzae

	Family	Species	Hosts
Larval parasitoid	Braconidae	*Bracon brevicornis*	Larvae of coconut black headed caterpillar
		Bracon hebetor	Larvae of coconut black headed caterpillar
		Chelonus blackburni	Egg-larval, Ha, Sl, Aa
		Cotesia plutellae	Larvae of diamondback moth
Larval – Pupal parasitoid	Ichneumonidae	*Isotima javensis*	Pre – pupal parasite of top shoot borer of sugarcane.
Pupal parasitoid	Ichneumonidae	*Xanthopimpla punctata*	Larval, Lepidopteran

C. blackburni

Isotima javensis

Bracon brevicornis

X. punctata

Pupal parasitoid	Eulopidae	*Trichospilus pupivora*	CBHC
		Tetrastichus israeli	Pre-pupal, Pupal, CBHC
	Chalcididae	*Brachymeria nephantidis*	Pupal, CBHC
	Epiricanidae	*Epiricania melanoleuca*	Nymphal, Pp
Nymphal and adult parasitoid	Aphelinidae	*Aphelinus mali*	Nymphal, Aphids
		Encarsia formosa	Nymphal, WF, MB, SC
		Encarsia favoscutellum	Nymphal, WF, MB, SC

Trichospilus pupivora

Tetrastichus israeli

B. nephantidis

Aphelinus mali

Order: Diptera (10% of parasitoid coming under this order)

Larval parasitoid	Tachanidae	*Eucelatoria bryani*	Larval, Lepidopteran
		Sturmiopsis inferens	Larvae of sugarcane early shoot borer
		Spoggosia bezziana	Larvae of coconut black headed caterpillar
Larval – pupal parasitoid		*Eucelatoria bryani*	Larvae of H.armigera

Sturmiopsis inferens

3. Based on host specificity

a. Monophagous parasitoid : Highly host specific attacking a single host species.

E.g. *Parasierola nephantidis* (Goniozus) (Bethylidoe) on *Opisina arenosella*(coconut black headed caterpillars).

b. Oligophagous parasitoid (Stenophagous): Attacking a group of related host species.

c. Polyphagous parasitoid: Attack a wide variety of host species.

(eg) *Trichogramma Spp*. (Trichogrammatidae) on eggs of many Lepidopteran species.

Parasierola nephantidis

4. Based on the host

a. Primary parasitoid: A parasitoid parasitizing a pest. It is beneficial

(eg) *Trichogramma sp.*

b. Seconday parasitoids: A parasitoid attacking another parasitoid. It is harmful

(eg.) *Opisina arenosella* (pest) *Bracon brevicornis*(Primary parasitoid) – *Pleurotropis sp.* (secondary parasitoid).

c. Tertiary parasitoid: A parasitoid attacking secondary parasitoid. It is beneficial.

(eg) *Trichospilus coerulescens*

All parasitoids whose hosts are parasitoids are called as hyperparasitoids (Parasitoids of Parasitoids).

***Bracon brevicornis* on BHC**

5. Based on the number of parasitoids developing from a single host insect

a.Solitary parasitoid:

One progeny alone is capable of completing its development in or on its host

(eg) *Eriborus trochanteratus.*

b. Gregarious parasitoid:

Several progeny are capable of completing its development in or on a single host. *(eg) Bracon breviconis.*

A further extension of gregaiousness is Polyembryony in which several individuals develop from a single egg. (eg) Platygaster.

Gregarious parasitisation

Kinds of insect parasitism

Simple parasitism: It is applied when there is a single attack of the parasitoid in the host, irrespective of the number of eggs laid.

Eg: *Goniozus nephantidis* on *Opisina arenocslla*.

Goniozus nephantidis

Super parasitism: When may individuals of the same species of the parasitoid attack a single host it is called super parasitism.

Eg: *Telenomus remus*

Telenomus remus

Multiparasitism: It means attack of different species of parasitoid on a single host. It is not beneficial for biocontrol.

Field applications.....

Species	Host/s	Quantity
Trichogramma chilonis	ESB/INB/OLE	1.50-2.50 Lakh/ha
Trichogramma japonicum	YSB/Sl/TSB/OLE	1.50-2.50 Lakh/ha
Trichogramma brasiliensis	Ha/OLP	1.50-2.50 Lakh/ha
Goniozus nephanidis	CBCP	15-20/plant
Bracon brevicornis	CBCP/OLP	25000-50000/ha, 10-15/plant
Bracon bebetor	GLM/OLP	25000-50000/ha, 10-15/plant
Chelonus blackburni	Ha/Aa/Sl/OLP	25000-50000/ha, 10-15/plant
Cotesia plutellae	DBM/OLP	25000-50000/ha, 10-15/plant
Trichospilus pupivora	CBCP/OLP	10-15/plant
Tetrastichus israeli	CBCP/OLP	10-15/plant
Brachymeria nephantidis	CBCP/OLP	10-15/plant
Sturmiopsis inferens	ESB/INB/TSB/OLE	250-500 /ha