

Insect Species Invasions And Its Effects On The Agricultural Ecosystem

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Alien or Invasive?

Alien species – a species that has been intentionally or unintentionally introduced to a location, area, or region where it does not occur naturally.

Invasive species – a species that has established and spread – or has the potential to do so – outside of its natural distribution range, and which then threatens ecosystems, habitats and/or other species, potentially causing economic and/or environmental damage, or harm to human health.

Aliens are also called:

- exotic species
- non-indigenous species
- non-native species
- introduced species
- colonizing species.

An alien species is considered invasive only if it has adverse impacts on the environment, the economy or human health

- ❖ Invasive Species - implies exotic and a threat to native species
- ❖ Exotic Species - from another part of the world
- ❖ Introduced Species - implies introduction but not a threat
- ❖ Alien Species - implies introduction to a particular ecosystem

Reasons for invasion:

- Invasive species are considered as the second greatest threat to native species, only behind habitat destruction.
- Increasing globalization of markets,
- Travel
- Tourism
- Alien species become invasive in introduced area due to absence of natural enemies and congenial environment parameters.
- Congenial conditions for the invading alien species.
- ✓ Richness of the varied agroclimatic zones

- ✓ Ecological disturbances.
- ✓ Habitat manipulation

Invasive spp. tends to be,

- Hardy
- Long lived
- Voracious
- Aggressively
- Rapid growth
- Ability to move long distances
- Prolific breeding
- Generalized diet

There are three categories for invasive insects

(i) Exotic insects on exotic plants.

- Spread of *Heteropsylla cubana* (Homoptera: Psyllidae) is a good example of exotic insects on exotic tree species.

(ii) Exotic insects on native plants

- Spiraling whitefly, *Aleyrodicus disperses*, is an example of an exotic insect invading native crops.
- This insect has been reported as feeding on more than 150 native species including fruit plants, vegetables and avenue trees.

(iii) Native insects on native plants.

- Rhinoceros beetle, *Oryctes rhinoceros* is an established pest of coconut palms in India.
- Recently it has become a problem for oil palm in southern states of India.

What influences invasion success?

1) Species Characteristics

- ✓ high fecundity
- ✓ small body size
- ✓ vegetative or asexual reproduction
- ✓ high genetic diversity
- ✓ high phenotypic plasticity
- ✓ broad native range

- ✓ abundant in native range
- ✓ physiological tolerance
- ✓ habitat generalist
- ✓ human commensal
- ✓ loss of natural enemies
- ✓ Invasional meltdown (negative impact on native ecosystems by invading sps)
- ✓ Polyphagy (*Aleurodicus dispersus*: host plants – 481 plants)

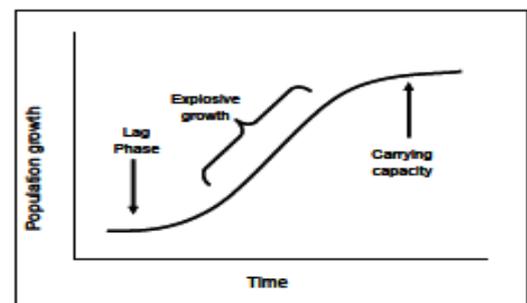
Evidence in support of these ideas is not always supportive, and sometimes contradictory

2) Generalizations Regarding Habitat Invasibility (Habitat characteristics)

- ✓ climatically matched
- ✓ disturbed
- ✓ low diversity
- ✓ absence of predators
- ✓ presence of vacant niches
- ✓ low connectance of food web
- ✓ nutrient rich (plants)

Stages of invasion:

Some alien populations not at all undergo lag phase and multiply rapidly in the new environment. Many alien population undergo a lag phase after initial establishment, and may remain unobtrusive/non-invasive for a long time before suddenly changing, becoming invasive and spreading rapidly. Some will fail to establish in the new environment.



Invasion model:

Ability of one genotype to produce more than one phenotype when exposed to different environments is called phenotypic plasticity. Plasticity and adaptive evolution can lead to greater invasiveness.

The main phases in the invasion process are:

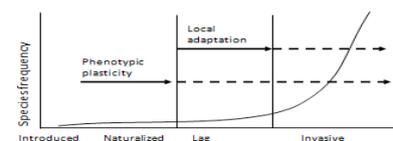
Phase 1: Introductions - Anthropogenic changes

Human activities have dramatically increased opportunities for species to travel around the world and to become invasive

- ✓ Trade, Tourism and Transport

Invasion model

- Plasticity and adaptive evolution can lead to greater invasiveness

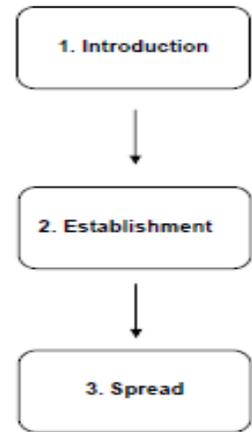
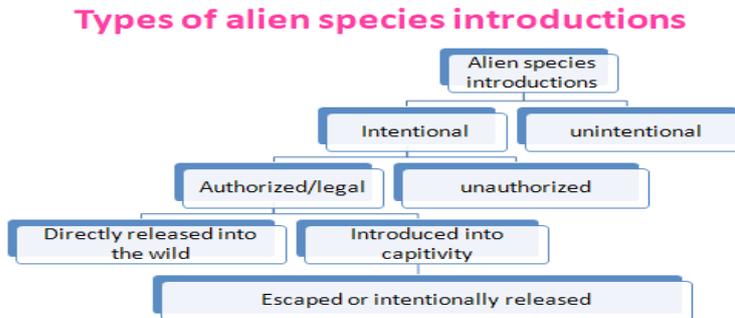


Sexton et al. 2002. *Ecological Applications* 12:1652-1660.

- ✓ Increased ‘propagule pressure’
- ✓ Selection pressures operating on IAS

Propagule pressure is directly linked to the number of individuals (or propagules) of a particular species that is introduced and the frequency thereof, as this increases the likelihood of a founding population being established.

Types of alien species introductions



Unintentional introductions (Potato tuber moth, *Phthorimaea operculella* was introduced with imported potatoes from Italy to India in 1937 and has spread throughout India)

Some pathways for the different types of introductions

Intentional Introductions		Unintentional Introductions
Direct Introductions into the Environment <ul style="list-style-type: none"> ▪ Agriculture ▪ Forestry ▪ Soil improvements ▪ Horticulture (ornamentals, nursery stock, house plants, etc.) ▪ Conservation ▪ Fishery releases ▪ Hunting and fishing ▪ Release of mammals on islands as food sources ▪ Biological control ▪ Aid trade ▪ Smuggling ▪ Aesthetics ▪ Medicinal ▪ Religious 	Introductions into Captivity/Containment <ul style="list-style-type: none"> ▪ Botanical and private gardens ▪ Zoos ▪ Farmed animals ▪ Beekeeping ▪ Aquaculture ▪ Pet trade ▪ Aquarium and horticultural pond trade ▪ Research 	<ul style="list-style-type: none"> ▪ Vessels/aircrafts/vehicles/trains, etc. ▪ Ballast water ▪ Hull fouling ▪ Sea cargo ▪ Sea containers ▪ Personal baggage/equipment ▪ Agricultural produce ▪ Seed contaminants ▪ Soil, gravel, sand, etc. ▪ Timber ▪ Packaging material ▪ Dirty equipment, machinery, vehicles - including military ▪ Hitchhikers – including parasites and diseases – associated with aquaculture introductions, cut flowers, and introductions for the nursery trade

- Serpentine leaf miner, *Liriomyza trifolii* that entered India accidentally probably with cut chrysanthemum flowers
- Accident release of organisms – gypsy moth, “Killer” African bees
- Coffee berry borer, *Hypothenemus hampei* introduced accidentally either through coffee brought by refugees from Sri Lanka.
- Blue gum chalcid, *Leptocybe invasa* introduction of this pest insect through exchange of vegetative materials of eucalyptus.
- Transfer in packing material -Horned Asian Beetle
- Pine woolly aphid, *Pinus pini* has moved into new areas mostly by movement of infested planting

stock.

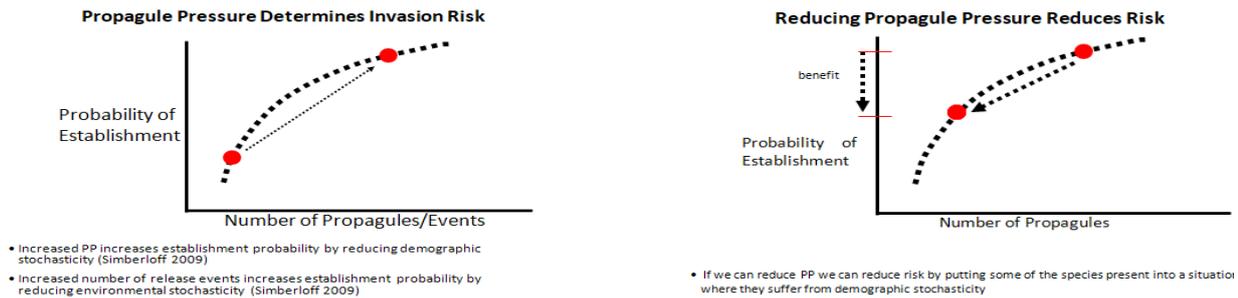
Phase 2: Establishment:

Establishment of alien pests mainly depend on

- number of introduction events
- number of propagules introduced per event
- condition of the propagules

Propagule pressure is a logical first step toward predicting invasion risk

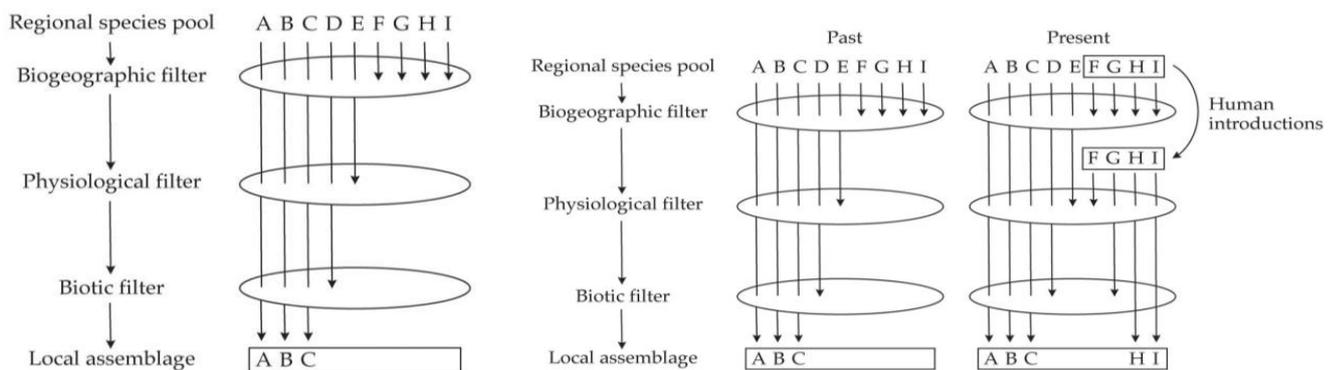
Successful establishment is related to propagule pressure, which refers to the number of species introduced



Phase 3: Spreading

- Spreading of a species into areas away from initial sites of introduction requires that the introduced species also overcome barriers to dispersal within the new region and can cope with the abiotic environment and biota in the general area
- Many IAS appear to first colonize disturbed habitats and some of these spread into seminatural communities usually requires that the alien taxon overcomes resistance posed by a different category of factors

Classical Model of Invasion



Invasive pests entered in India

Scientific name	Common name	Year of introduction
<i>Eriosoma lanigerum</i>	woolly apple aphid	1889

<i>Quadraspidiotus perniciosus</i>	San Jose scale	1911
<i>Orthezia insignis</i>	Lantana bug	1915
<i>Icerya purchasi</i>	Cottony cushion scale	1921
<i>Phthorimaea operculella</i>	Potato tuber moth	1937
<i>Plutella xylostella</i>	Diamond-back moth	1941
<i>Pineus pini</i>	Pine woolly aphid	1970
<i>Heteropsylla cubana</i>	Subabul psyllid	1988
<i>Liriomyza trifolii</i>	Serpentine leaf miner	1990
<i>Aceria guerreronis</i>	Coconut eriophyid mite	1997
<i>Bemisia argentifolii</i>	Silver leaf whitefly	1999
<i>Leptocybe invasa</i>	Eucalyptus gall wasp	2001
<i>Quadrastichus erythrinae</i>	Erythrina gall wasp	2005
<i>Leptocybe invasa</i>	Blue gum chalcid	2006
<i>Phenacoccus solenopsis</i>	Cotton mealybug	2006
<i>Paracoccus marginatus,</i>	Papaya mealy bug	2007
<i>Tuta absoluta</i>	Tomato pin worm	2014
<i>Aleurodicus rugioperculatus</i>	Rugose whitefly	2016
<i>Spodoptera frugiperda</i>	Fall army worm	2018
<i>Paraleyrodes bondari</i>	Bondar's nesting whitefly	
<i>Phenacoccus manihoti</i>	Cassava mealybug	2020

Do they evolve??

Soapberry bugs *Leptocoris tagalicus* that are native to Australia have evolved genetically based changes in the length of their mouthparts that increase feeding efficiency on a balloon vine *Cardiospermum grandiflorum*. Introduced fruit flies in Africa *Drosophila subobscura* show rapid heritable changes in morphology.

Evolution of Increased Competitive Ability Hypothesis (EICA)

- ✓ applied to plants
- ✓ Under identical growing conditions, species will produce more biomass in an area where it has been introduced vs. in its native range.
- ✓ Invasive species will exhibit lower herbivore defense rates in introduced range than in native range.

Impacts of species Invasions:

Ecological Impacts

- ✓ Direct predation/herbivory
- ✓ Competition for resources
- ✓ Habitat alteration
- ✓ Spreading pathogens and parasites

- ✓ Upsetting ecological balances and interactions
- ✓ Synergies with other IAS, such as degrading the environment so that further invasions are facilitated
- ✓ Invasive organisms flourish and are capable of displacing native biota
- ✓ On soil chemistry
- ✓ Hydrology: Alterations of Water Regimes
- ✓ Geomorphological processes (erosion, sedimentation)
- ✓ Invading species affect ecosystems by altering or replacing natural systems through:
 - ✓ competition, exclusion, predation, parasitism, pathogenesis,
 - ✓ Alteration of: micro-climate, nutrient availability, ecosystem cycles (energy, water, minerals, organics) – affecting: Ecosystem function, health, goods and services
 - ✓ The impacts of IAS on natural ecosystems are usually irreversible
 - ✓ Disturbing ecological processes and thereby facilitating invasion by other alien species
 - ✓ Altering of the food web and nutrient cycles
 - ✓ Spreads human, Plant and Animal Diseases

Economic impacts

Along with irreplaceable losses to biodiversity there is losses in billions per year due to loss of agricultural productivity, forest productivity and recreational opportunity.

Impact of invasive spp. to the agro ecosystem

Displacement of native species

- *C. partellus* into Africa has been displacement of native stemborers *Chilo orichalcociliellus* and *Sesamia calamistis* being of minor importance
- *C. partellus* completes a generation in less time and diapause termination.

Purposefully introduction became invasive

Several bee species have been introduced into countries far beyond their home range, including *A. mellifera*, *Bumblebees (Bombus sp.)*, Alfalfa leafcutter bee *Megachile rotundata*

Climate change on invasive species

Global warming and the globalization of trade have a decisive impact on the geographical distribution of insects. At the same time, global warming is promoting the expansion of many insect species northward and to higher altitudes (beetles, dragonflies and grasshoppers over the past 30 years). These two factors combined explain the multiple insect invasions observed in recent years.

Measures to prevent pest incursions

When a new or exotic pest is reported for the first time, no serious thought is given to contain and eradicate the

pest through concerted efforts by the stakeholders. When the same pest assumes an epidemic form, measures are initiated to control the pest to minimize the damage. The agricultural trade is increasing many folds and consequently the looming pest threats are also increasing. Coconut hispid beetle (*Brontispa longissima*) is one of the economically important pests of coconut and is polyphagous, which has already invaded into neighbouring countries such as Maldives and Myanmar, is a looming threat to India.

Benefits of invasive species:

Some biological invasions bring benefits as well as costs – to local people and development, e.g.

- Water hyacinth can be used for biogas, compost, stock food, furniture
- Mesquite can reduce erosion, produce timber and charcoal
- Lantana stems are used for chicken cages

But it is rare that the benefits exceed the costs or can pay for the necessary control

Ecosystem restoration

- Amongst the objectives for invasive species management, there is often a wish to return the affected system to its original status
- This requires a set of actions together referred to as ecosystem restoration – including:- returning lost species, understanding biological succession, and, addressing needs of stakeholders

The use of other potentially invasive species should not be used – even if it can speed up the restoration!

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