Biological invasions in Australia and New Zealand

1. What are biological invasions?

2. Traits commonly associated with invasion success

3. Australia & New Zealand

4. How can we control invaders?
Biological invasions have many unintended consequences
Lantana camara invasion in India threatens Tiger habitat
Brown tree snake invasion on Guam

• probably introduced as a ship stowaway in 1940’s from South Pacific

• Has devastated forests and eliminated most native vertebrates; has also caused much human trauma because of home invasions
Spectacular adaptive radiations of cichlid fish in Great African lakes

- ~ 2000 species - Lake Tanganyika 9-12 million yrs old - 250 spp; Lake Malawi 2-5 million yrs - 1000 spp; Lake Victoria < 200,000 yrs old 500-1000 spp.

- The lakes have experienced independent evolutionary radiations producing striking arrays of eco-morphological diversity e.g. plankton scrapers, algae scrapers, egg predators, piscivores etc

- Habitat specialists have evolved by convergent evolution in 2 or 3 lakes.

Introduction of the Nile Perch to African Lakes has resulted in the extinction of many endemic Cichlid species
The battle to prevent ‘Asian Carp’ invading the Great Lakes

Estimated that $30 million spent in 2010 to prevent the invasion
Biological invasions

The successful establishment of a species in a region not previously occupied followed by rapid range expansion

Biological invasions do not always involve harmful species but most do
Changing Perspectives on Invaders

THE GENETICS OF COLONIZING SPECIES
EDITED BY H. G. Baker and G. Ledyard Stebbins

Invasive Species in a Changing World
EDITED BY Harold A. Mooney and Richard J. Hobbs
Terms Used to Describe the Origins of Species

Native

• An indigenous species that occurs wild in a given region

Alien

• A species that has been introduced to a part of the world to which it is not native
• Also referred to as **adventive**, **exotic** or simply **introduced** species
Negative environmental consequences of biological Invasions

- Disrupt ecological processes in natural plant & animal communities
- Displace native species leading to their extinction
- Adverse effects on human health
- Serious economic & social impacts through reduction of yields in agriculture & fisheries
Invasive species in the USA

• Economic cost = $120 billion per year

• 50,000 introduced species, number rising

• ~ 42% of threatened & endangered species at risk primarily due to alien invasives

Questions on invading species

• Why are invading species usually only aggressive in their introduced not native ranges?

• Are certain ecosystems more susceptible to invasions than others?

• What are the ecological & genetic characteristics of successful invaders?

• Is there evidence for the contemporary evolution of local adaptation in invaders?

• How can invaders be controlled?
Differences in enemy attack in populations of white campion (Silene latifolia) from Europe and North America: an example of the enemy release hypothesis


- pest and disease pressure was x17 times higher in the native range compared to the alien range and involved both specialist and generalists
Invasive species thrive in disturbed sites: the more disturbance the more vulnerable to invasion

Caused by humans (Amazon forest) Natural (volcanic eruption)

Forms of Disturbance
Pampas grass invasion along abandoned fire trail in chaparral vegetation

Cortaderia selloana

California
Native and introduced Cortaderia spp in New Zealand – 5 native, 2 introduced
Common attributes of successful invasive species

• Rapid development to reproduction
• High reproductive output
• Well-developed dispersal mechanisms
• Broad ecological tolerance
• High phenotypic plasticity*

* The ability of a genotype to alter its phenotype in response to environmental change – important trait in unpredictable environments
Short 5 minute break and questions
Wetland invasions

Purple loosestrife (*Lythrum salicaria*)

- Aquatic perennial with showy purple flowers native to Europe; used as an ornamental.
- Multiple introductions to eastern North America during past century followed by invasion of wetlands.
Early colonization by purple loosestrife on the Leslie Street Spit, Toronto

Lythrum salicaria
Lythraceae
Purple loosestrife invasion in eastern Ontario
Purple Loosestrife in China
Some attributes of purple loosestrife

- Plants competitive with high phenotypic plasticity, produce millions of small, easily dispersed seeds with high viability

- Populations genetically diverse due to multiple introductions, outbreeding and polyploidy; provides opportunities for evolution of local adaptation
Is there evidence for rapid adaptive evolution in invasive populations of Purple Loosestrife?
Rob Colautti’s Common Garden Experiment
At Koffler Scientific Reserve (KSR)
Common garden experiment at KSR -2009

Rapid Adaptation to Climate Facilitates Range Expansion of an Invasive Plant
Robert I. Colautti and Spencer C. H. Barrett
Science 342, 364 (2013);
DOI: 10.1126/science.1242121
Flowering time correlated with latitudinal gradient of seasonality

- common garden studies indicate significant genetic differentiation among populations
- variation forms a cline* in time to flowering with northern populations flowering faster than southern populations
- populations farther north have adapted to shorter growing season

* A gradual change in trait means over a geographical transect
Aquatic plant invasion in the tropics

The world’s worst aquatic invaders:

• Water hyacinth (*Eichhornia crassipes*)
• Kariba weed (*Salvinia molesta*)

Features in common:

• Native to South America, introduced by humans to Old World tropics, free-floating with prolific clonal propagation, populations genetically uniform and invasiveness due to high phenotypic plasticity NOT genetic diversity

• Herbicide control causes pollution of aquatic habitats so biological control methods used
Water hyacinth clonal & sexual reproduction
Water Hyacinth blocks river in Vietnam
River in Louisiana clogged with water hyacinth
Distribution & spread of water hyacinth

Native to lowland South America but now worldwide
In tropical & warm temperate regions
Kariba weed is a floating fern that is genetically sterile.
**Biological invasions in Australia**

- Most invaded continent because an island and its biota are largely endemic and vulnerable to introduced predators and pathogens.
- Many invasions associated with formation of “Acclimatization Societies” in late 1800s by Europeans.
- Introduction of fox and cat caused extinction of 20 marsupials and all native mammals weighing between 35 g - 5.5 kg.
- European rabbit perhaps worst pest, introduced in 1858 but now occupies 4 million km² and has devastated native vegetation, pasture & crops.
- Prickly pear another disaster before biological control.
Cane toad invasion of Tropical Australia

• Cane toad (*Bufo marinus*) native to neotropics and introduced to Puerto Rico & Hawaii where it successfully controlled cane beetles devastating sugar cane crops

• Later introduced to Australia but not successful in reducing beetles, multiplied prolifically and is reducing biodiversity, especially reptiles

• Now evidence that it is evolving better dispersal in Australia – Richard Shine (University of Sydney)
Plant invaders in Australia
Paterson’s Curse or Salvation Jane

- Introduced from Europe ~1880 as an ornamental and seed contaminant of pastures
- Now a dominant pasture weed in southern Australia and infests native grasslands
- Contains alkaloids and is poisonous to cattle and horses leading to efforts at biological control
Not all Echium spp are invasive but some are rare

- *Echium* (Boraginaceae) has 60 species

- The biennial giant *Echium wildpretii* is a rare endemic to Canary islands

- Adapted to specialized habitat - volcanic slopes of El Teide on Tenerife, grows to 3m
Bermuda buttercup invasions

- *Oxalis pes-caprae* native to South Africa now invaded all Mediterranean regions – Europe, California, Chile, Australia

- Invasive populations largely composed of a sterile pentaploid (5x) that reproduces clonally by bulbils

*Molecular Ecology* 2015
Biological invasions in New Zealand

• New Zealand ranks among the most highly invaded areas on earth

• Largest number of introduced mammals of any country on earth

• Second highest number of introduced birds

• ~1800 alien plant species, represents 50% of total flora

• New Zealand economy loses $840 million or ~1% GDP

Williams & Timmins 2002
Plant invaders of diverse origins in New Zealand

Gorse – *Ulex europaeus*

Sweet briar – *Rubus rubiginosa*

Purple groundsel – *Senecio elegans*

California poppy – *Eschscholzia californica*
Animal invaders in New Zealand
The common brushtail honey possum

- Deliberately introduced from Australia in 1850s for food and pelts
- By late 1980s population estimated at 60-70 million
- A major vector for bovine tuberculosis affecting dairy, beef and deer farming
- Also damages native vegetation as flora evolved in the absence of mammalian omnivores
Management of invasive species
How can we control them?

• mechanical e.g. hand weeding, machines
• chemical – herbicides
• ecological e.g. burning, flooding
• biological control
Biological control of invaders

• The planned introduction of natural enemies (e.g. predators, parasites, pathogens) to control unwanted populations of invaders in alien range
Mode of reproduction of plant invaders & likelihood of success from biological control

- Asexual species easier to control than sexual species
- Why?
- Answer lies in influence of reproductive systems on genetic diversity
- Genetic diversity will determine whether resistance evolves

Kariba weed is a floating fern that is genetically sterile.
Advantages of biological control

- Non-toxic to humans; if conducted carefully no serious environmental impacts
- If successful the effects are permanent
- Economically cheap ($1 for biological control vs. $5 for chemical control)

Danger of biological control
Sloppy science creates new invasion
Today’s General Messages

• Biological invasions reduce biodiversity and are a serious financial drain on the global economy

• Understanding why some species are invasive is a key biological question

• Genetic and ecological studies can provide insights for management of invasives

Further Reading

http://islandpress.org/bookstore/details0620.html?prod_id=830