Behavioral approaches to the study of biological invasions.

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Researchers in Germany found that road noise affected the bats' ability to listen for the "rustling sound" of the beetles and spiders they feed on. This is the first study to examine the impact of traffic on predators that listen for their prey. The researchers report that the same effect could be true for other "acoustic predators", including owls.

Greater mouse-eared bats eat large, ground-running creatures, such as carabid beetles, hunting spiders and centipedes. With their remarkably sensitive hearing, the bats detect and track down their prey by listening for the faint rustling sounds they produce when walking.
The Role of Behavior in Conservation

Issues in Conservation Biology that can benefit from the study of Animal Behavior:

Captive Breeding and Reintroduction

Species Management Plans

Habitat Loss and Fragmentation

Biological Invasions
**Definitions**

**Introduced** (*non-native, exotic*)
- species introduced deliberately or accidentally from somewhere else.

**Domestic/Feral** (*released pets, livestock and game animals*)
- can spread disease, compete with native species.

**Human commensal or subsidized** (*out of control natives*)
- native species that benefit from disturbance.

**Invasive species**
- species that spread subsequent to establishment and have some economic or ecological cost.
Why study biological invasions?

Consequences
threaten biodiversity
costly
widespread
Estimated annual costs associated with non-native species:

<table>
<thead>
<tr>
<th>Group</th>
<th>costs (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants (purple loosestrife, weeds)</td>
<td>34</td>
</tr>
<tr>
<td>Mammals (feral pigs, rats)</td>
<td>37</td>
</tr>
<tr>
<td>Birds (pigeons, starlings)</td>
<td>2</td>
</tr>
<tr>
<td>Fishes</td>
<td>1</td>
</tr>
<tr>
<td>Arthropods (ants, termites, other pests)</td>
<td>19</td>
</tr>
<tr>
<td>Mollusks (zebra mussel, asian clam)</td>
<td>1</td>
</tr>
<tr>
<td>Microbes (plant pathogens, animal disease)</td>
<td>41</td>
</tr>
<tr>
<td>All organisms</td>
<td>over $136 billion per year</td>
</tr>
</tbody>
</table>

Pimentel et al. 2000 BioScience
Why are species declining?

Percentage of threatened or endangered species in the U.S. imperiled by:

- Habitat degradation and loss - 85%
- Invasive species - 49%
- Pollution - 24%
- Overexploitation - 17%
- Disease - 3%

Wilcove et al. 1998 BioScience
Displacement or replacement?

Homogenization

“Process in which a mixture is made uniform throughout”.

Biotic homogenization

Increasing similarity among areas in terms of species identity.

Habitat loss and modification coupled with the widespread introduction of a few species leads to homogenization.
Why study biological invasions?

Unique opportunities for basic research
community ecology
evolution
animal behavior
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Unique opportunities for basic research
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Cricket and phonotactic parasitoids
Zuk et al. 1998 Evolution

Increasing duration of chirps, # of chirps, duration of song
The Role of Behavior in Invasion Biology

Understanding establishment success
sociality and allee effects

Determining patterns and rate of spread
dispersal (natural versus human mediated)

Competitive displacement of native species
behavioral mechanisms of success
response of natives to introduced species
Paradox: How are introduced species so successful when they share no co-evolutionary history with their new environment?
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Hypotheses for the success of introduced species:

- Escape from natural enemies
  (predators, parasites, disease)
- Increased competitive ability
  (outcompete native species)
- Pre-adapted to disturbed environments
Determining patterns and rate of spread

**Dispersal:** Ecological process affecting distribution. 
*Largely a short range effort; can be very costly!*

“Forecast and control of epidemics in a globalized world.” Hufnagel et al. PNAS 2004
Stages of invasion

1. Opportunity (transport)
2. Establishment
3. Spread

(different characteristics may be important at different stages)
What can we learn from studying ant interception records?

- year / month when intercepted
- port of entry
- port of departure (source)
- substrate
- collector (often)
- identity and amount of material (ants)
Where are ants intercepted in quarantine in N.A. coming from? 

Based on interception records from 1920-1970s
Where do insects introduced to N.A. come from?

66.2% Western Palearctic (i.e. Europe)

Fig. 4. Origins of the immigrant arthropod fauna, with the total number of recorded species and the percentage of species contributed by different world biogeographic regions. (Prepared by Limhout Nong.)
What do we learn from examining interception records?

Information on which countries / ports we are most likely to receive ants from.

Allows analyses of determinants of invasion success to include biogeographic factors, abiotic similarity, economic indicators, commerce…

Helps prioritize inspection as records include the type of commerce ants were detected on.
How important is opportunity?

Linepithema humile  
Linepithema iniquum

from 1923 – 1960:

- *Linepithema iniquum* 32.5%
- *Linepithema humile* 12.5%
- *Linepithema dispertitum* 10.0%
- *Linepithema pilliferum* 7.5%
- *Linepithema melanum* 7.5%
- *Linepithema angulatum* 2.5%
- *Linepithema luecomelas* 2.5%
Determining patterns and rate of spread

Disperse far and fast
stay in groups

Be bold and exploratory
role of behavioral syndromes?

Be behaviorally flexible
need bigger brains?
Cane toad

Native to New World.

Introduced to Australia to control insects in sugar cane.

Milky secretions are highly toxic. Kill pets and many native animals.
SYDNEY (Reuters) - A huge cane toad the size of a small dog has been captured in the Australian tropical city of Darwin, startling environmentalists who are fighting to stop the poisonous amphibians spread across the country.

“It’s a monster toad,” said Paul Cowdy from FrogWatch which captured the cane toad on Monday night. “We’ve never seen a cane toad this big,” he said on Tuesday. “It’s a male and normally females are bigger.”
Figure 1 | Morphology of cane toads in relation to their speed and invasion

Phillips et al. 20006, Phillips et al. 2008
The accelerating rate of invasion of cane toads across northern Australia (a), is associated with evolutionarily increased dispersal rates on the expanding range edge (b).

Phillips et al. 20006, Phillips et al. 2008
Relationship among foraging activity, intraspecific aggression and boldness in the invasive signal crayfish. All correlations are significant (p < 0.05) and are based upon comparisons of population means. (redrawn form Pintor et al. 2008)
“Argentine ants are fiercely intolerant of all other kinds of ants and, where they are numerous, they quickly exterminate all our native ants”

S. H. Skaife
The Role of Behavior in Invasion Biology

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sociality and allee effects

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response of natives to introduced species
Linepithema humile & Solenopsis invicta in South America

native range of L. humile from Wild 2004

native range of S. invicta from Mescher 2003
Solenopsis invicta

Laboratory Experiments

Field Experiment

Wildier et al. 2012
Ants have different colony structures

Unic colony structure seen in some of the most widespread invasive ants. Also linked to other traits:
- Polygyny
- Colony budding
Variation in colony structure in *humile* clade

- *L. humile* introduced
- *L. humile* native
- *L. oblongum*
- *L. micans*
- *L. gallardoi*
- *L. neotropicum*
- *L. iniquum*
- *L. pilliferum*
- *L. tsachila*
- *L. angulatum*
Animal behavior: an essential component of invasion biology

David A. Holway
Andrew V. Suarez

A major challenge of invasion biology lies in the development of a predictive understanding of invasion processes. Attempts to identify the proximate causes of invasion success or to predict rates of spread seldom emphasize behavioral characteristics. Recent experimental work, however, illustrates that insight into the proximate causes of animal invasions often hinges on a careful assessment of behavioral mechanisms. For this reason, behavioral analyses should be more fully integrated into research on biological invasions. In addition to enhancing a general understanding of invasion processes, such approaches provide potentially underused opportunities for basic research in animal behavior.

CHAPTER 14

The role of behavioural variation in the invasion of new areas

Ben L. Phillips and Andrew V. Suarez

Overview

Behaviour determines the rate at which invasive species spread, as well as the impact they have on natives. When behaviour varies between individuals (as it almost always does), then the mean behaviour is often less important than the extremes of behaviour. The rate at which a species spreads, for example, is governed primarily by the most extreme dispersers. Similarly, individuals of native species that are extreme in their behaviour may be more, or less, likely to suffer impact from a given invasive species. Thus, we argue, an understanding of behavioural variation is critical if we are to understand the long-term impacts of invasive species in a changing world.
How can correlated traits select for individuals that are pre-disposed for invasion success?

No correlation  
Behavioral Syndrome  
Trade-off  
Breaking Trade-off