Insect Behavior!
Anne Leonard

My research:

Bumble bee behavior
Plant-pollinator interactions
Floral signal evolution
Learning, signals and uncertainty: Perspectives from plant-insect interactions

Daniel Papaj
Professor
University of Arizona

Thursday, April 25th
4 pm
DMS 103
Thursday!

4 pm
DMS 103
Western field cricket
*Gryllus integer*
Today

What makes study of *insect* behavior special?
Today

What makes study of *insect* behavior special?

Vs.
Lifespan?

(Many insects used heavily in research do have short generation times → Experimental evolution)
Complexity of social interactions?
“Complexity” in general?

Mycoplasma
Gram positive bacteria
Gram negative bacteria
Fungi / Molds
Algae
Worms
Crustaceans
Echinoderms
Insects
Mollusks
Birds
Bony fish
Cartilaginous fish
Reptiles
Mammals
Amphibians
Flowering Plants

in bp

$10^6$ $10^7$ $10^8$ $10^9$ $10^{10}$ $10^{11}$
Brain size?
# neurons?

100,000

960,000

1,000,000,000

85,000,000,000
Is bigger always better?
Today

What makes study of **insect** behavior special?

Nothing*, really!

Vs.

Except that, in practical terms, insects are:

- (Often) cheaper and **easier** to study
- More opportunities for comparative studies
- Often research funded by diverse entities
  (USDA; NIH; NSF; Bill & Melinda Gates Foundation etc.)
“It is certain that there may be extraordinary activity with an extremely small absolute mass of nervous matter; thus the wonderfully diversified instincts, mental powers, and affections of ants are notorious, yet their cerebral ganglia are not so large as the quarter of a small pin’s head.

Under this point of view, the brain of an ant is one of the most marvellous atoms of matter in the world, perhaps more so than the brain of man.”

Charles Darwin 1871
Insects

“Hard-wired” robots

A traditional and common view
Cognition?
(Decision-making, learning + memory)
Insects have...

• Short term (minutes) and long-term memory (days/weeks)
  – Honeybees learn certain stimuli faster than infants
  – Color learning faster than many vertebrates

• How to study insect learning and memory?
  – (Many ways)
Sucrose reward

Empty

Colors, patterns, textures, scents, shapes,
Degrees of symmetry, temperatures, orientations,
times of
day, spatial locations...etc

% landings on

Landing number
Classical conditioning of the Proboscis extension response (P.E.R.)
Classical or Pavlovian conditioning

Before training:
Unconditioned Stimulus $\rightarrow$ Unconditioned Response

- Presence of dog food $\rightarrow$ Drooling
- Presence of sucrose $\rightarrow$ Proboscis extension
- Bacteria in your food $\rightarrow$ Nausea

During training:
Conditioned Stimulus + U.S. $\rightarrow$ Unconditioned Response

- Bell ringing + Presence of dog food $\rightarrow$ Drooling
- Scent or Color + Presence of sucrose $\rightarrow$ Proboscis extension
- Taste or smell of food + Bacteria in your food $\rightarrow$ Nausea

After training:
Conditioned Stimulus $\rightarrow$ Conditioned Response

- Bell ringing $\rightarrow$ Drooling
- Scent or Color $\rightarrow$ Proboscis extension
- Taste or smell of food $\rightarrow$ Nausea

Learning!
Conditioning of Proboscis

- Extension of proboscis (UR)
- Odor (CS)
- Sugar water (US)
Some insects have...

- The capacity to learn rules and generalize them across sensory modalities (color + scent)

Delayed match-to-sample task
Some insects have...

Sensory systems that match or surpass ours
Sensory systems can have similar degrees of sensitivity to wavelengths of light.
• Bees have similar degrees of sensitivity to wavelengths of light
Mantis Shrimp: Extraordinary Eyes

Homo sapiens

Neogonodactylus oestedii

Marshall et al., 2007; Marshall and Oberwinkler, 1999
Jumping spiders

- Video
Some insects have...  

Symbolic communication:  

*The waggle dance*
Some insects have...

Symbolic communication:
The waggle dance

Orientation = relative to sun
Duration = distance
Insects

“Hard-wired” robots

A traditional and common view

More nuanced perspective:

Just like most other organisms, situations where learning and flexibility pay off...

And situations in which an innate response is more efficient...
Expect learning to evolve when within-generation predictability is HIGH and between-generation predictability is LOW.

**Within-generation predictability**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>LEARN!</td>
</tr>
<tr>
<td>High</td>
<td>Innate response will do just fine</td>
</tr>
</tbody>
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Stephens, 1991