Polistes paper wasps

Cooperative breeding and communication

Paper wasp natural history

- Primitively eusocial wasps
- Global distribution: >500 species in genus >5000 species in family (Vespidae)
- Little caste differentiation (i.e. queens and workers are very similar)
- Make nests out of wood pulp
- Wasps eat caterpillars and nectar.

Nest cycle

Nests are initiated either by a single female or a group of cooperating females
- Cooperative nests tend to have higher rates of survival
- Reproduction is not evenly shared among foundresses

Why do fertile foundresses cooperate to rear a nest?

Why cooperate?

- Multi-foundress nests tend to have:
  1) Higher rates of survival
  2) Higher per-capita rates of reproduction.

Why cooperate?

- Dominants benefit from cooperation.
- But why do subordinates cooperate?
**Why cooperate?**

3 reasons for subordinate cooperation in paper wasps

1. Low opportunity cost
2. Direct Benefits
3. Indirect Benefits

**Compare the two options**

Fitness when solitary

In many species single foundress nests always fail

Fitness when subordinate

Lower than dominant but often greater than zero

**Direct benefits of cooperation:**

Subordinates in *P. dominulus* populations in Spain have elevated fitness relative to solitary individuals

**Why cooperate?**

3 reasons for subordinate cooperation in paper wasps

1. Low opportunity cost
2. Direct Benefits
3. Indirect Benefits
Indirect Benefits

\[ r \times b > c \]

- \( r \) = Relatedness to recipient
- \( b \) = Benefit to recipient
- \( c \) = Cost to actor

**Fitness can be gained through acts that increase reproductive output of relatives**

Hamilton’s rule

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Indirect Benefits – an example

Two wasps can either cooperate to rear a nest of found nests separately.

If they found nests separately each wasp will have 10 offspring.

If they cooperate, the dominance wasp will have 20 offspring and the subordinate will have 5 offspring.

Should the subordinate cooperate?

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Should the subordinate cooperate?

What about if relatedness is .75?

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Indirect Benefits?

<table>
<thead>
<tr>
<th>Species</th>
<th>Relatedness among co-foundresses</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. dominulus</em></td>
<td>39.5% Queller et al (2001)</td>
</tr>
<tr>
<td><em>P. fuscatus</em></td>
<td>50 ± 0.06 % Reeve et al (2000)</td>
</tr>
<tr>
<td><em>P. carolina</em></td>
<td>64 ± 0.06 % Seppä et al (2002)</td>
</tr>
<tr>
<td><em>P. bellicosus</em></td>
<td>67 ± 0.04 % Field et al (1998)</td>
</tr>
<tr>
<td><em>P. olivaceus</em></td>
<td>74 ± 0.03% Kudr &amp; Tsuchida (2012)</td>
</tr>
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Reproductive skew in *P. fuscatus*

**Partitioning of reproduction among foundresses can be complicated!**

Example from *P. carolina*

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Variable color patterns are used to manage conflict among queens

**Polistes fuscatus**

“The North American *Polistes*, like those of other parts of the world, are quite variable in the extent, arrangement and shade of color markings. The extreme case is perhaps that of *P. fuscatus*, in which color seems to run riot and to defy any attempt at rational analysis.”

Bequaert (1940) *J NY Ent Soc*

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**Individual Recognition Experiment**

**Faces are special for humans**

Tibbetts 2002


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**Faces are special for humans**

But specialization isn’t necessary....
Demonstrating cognitive specializations for face processing

1. Wasps learn to discriminate faces more quickly and accurately than other images

   vs.


2. Normal faces are learned more quickly and accurately than manipulated faces

   vs.


P. fuscatus face learning

<table>
<thead>
<tr>
<th>Percent correct</th>
<th>Faces</th>
<th>Patterns</th>
<th>Caterpillars</th>
</tr>
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<tbody>
<tr>
<td>P &lt; 0.003</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>P &lt; 0.0001</td>
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Is specialization adaptive?

Specialized face learning should be associated with the evolution of facial recognition

P. fuscatus

Convergent evolution of specialized face processing between wasps and primates

Is specialization adaptive?

Species lacking IR should lack specializations for face learning

P. fuscatus

P. metricus

No IR

Close relative
Adaptive specialization for face learning

Convergent evolution between wasps and primates
Different optical and neural structures

Divergence between two closely related paper wasps
Sympatric, very similar ecology

Conflict management

More dominant individuals have more broken or wavy black marks on their face (more spots = stronger wasp)

Wasps with more spots are more likely to win a fight

How to demonstrate a quality signal

- Correlation between trait and condition
- Correlation between trait and fitness
- Manipulative experiment needed to show that proposed trait is actually conveying information
Experiment to show signaling function

Paint faces of two wasps with the same initial signal to be either low or high signals.

Let a focal wasp choose which individual it is more willing to challenge.

Video...

Guard challenged for food

![Bar chart showing number of trials for low and high quality wasps.](Tibbets & Lindsay 2008)

Do the wasps know their own face?

Behavior and facial pattern are correlated.

What allows for a correlation?

Condition dependence

Signals and behavior are both condition dependent

Better nutrition = better fighter = stronger signal

![Bar chart showing mean brightness of offspring facial patterns.](Tibbets & Curtis 2007)

Individual Recognition

- Nametag
- Many variable color patterns
- Remember individuals
- Requires interaction
- Cognitively complex

Quality signal

- Karate belt
- One variable color pattern
- Useful in interactions with unfamiliar individuals
- Condition dependent
- Cognitively simpler

P. fuscatus

P. dominulus