

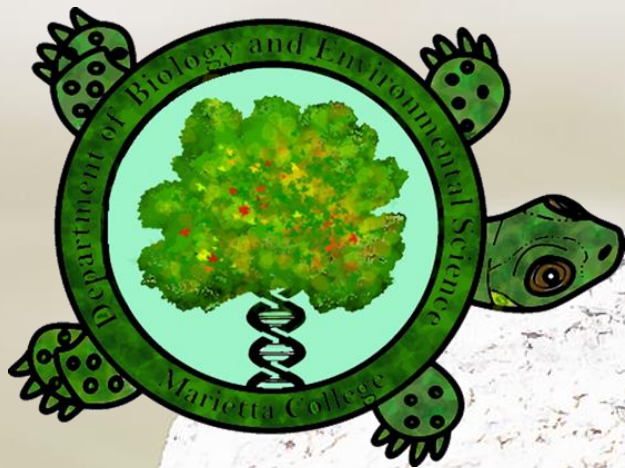
Making and Testing Hypotheses in Natural History:

Microhabitat Selection by *Hetaerina americana* and *Hetaerina titia*

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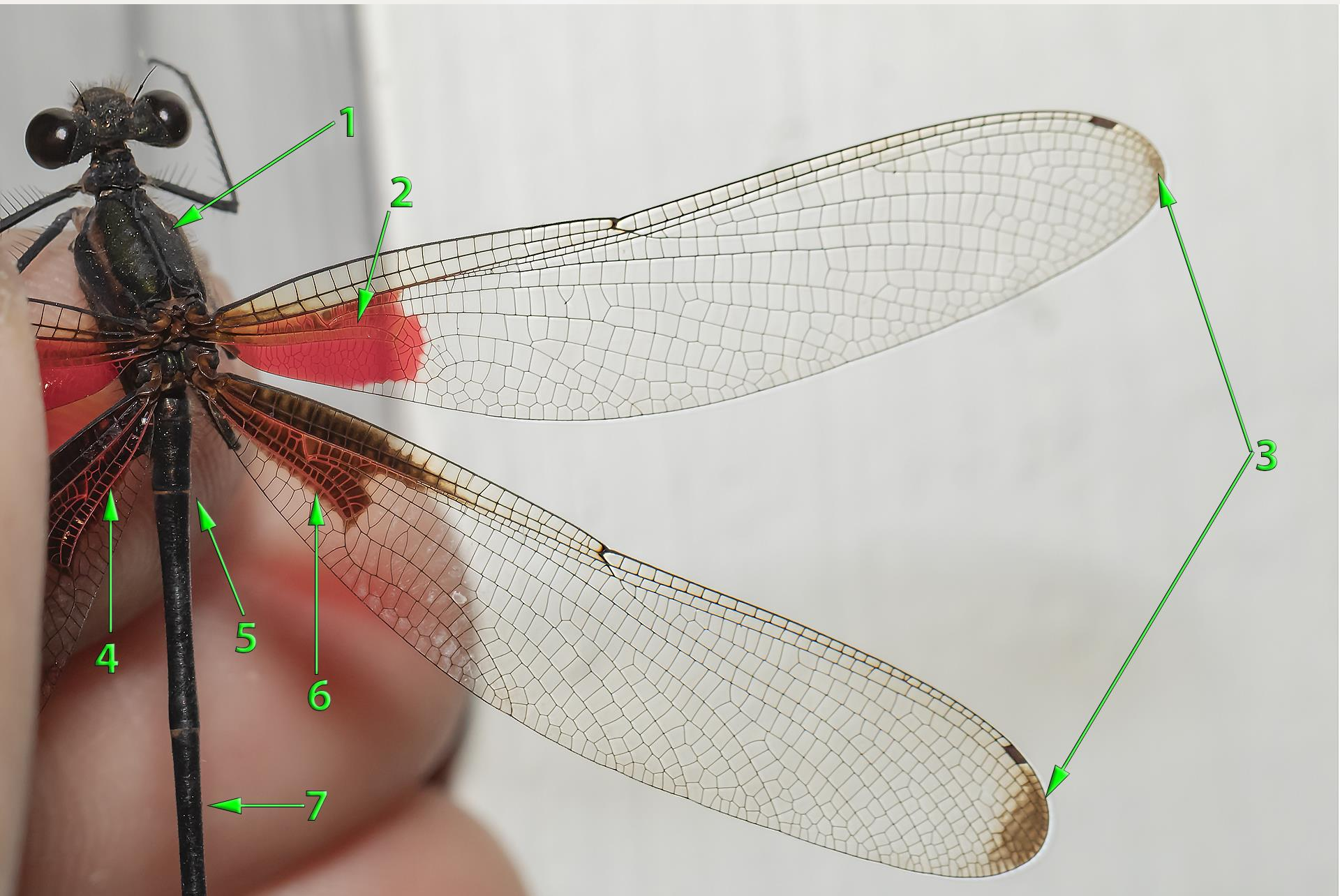


A tale (tail?) of 2 species...

- *Hetaerina americana* and *Hetaerina titia* (American and Smoky Rubyspots, respectively) are two closely related species of damselflies found in Ohio.
- Ecological and evolutionary theory holds that closely related species will diverge in some way so that
 - a) they do not compete as strongly.
 - b) they do not intermate (which would cause them to go back to being one species).

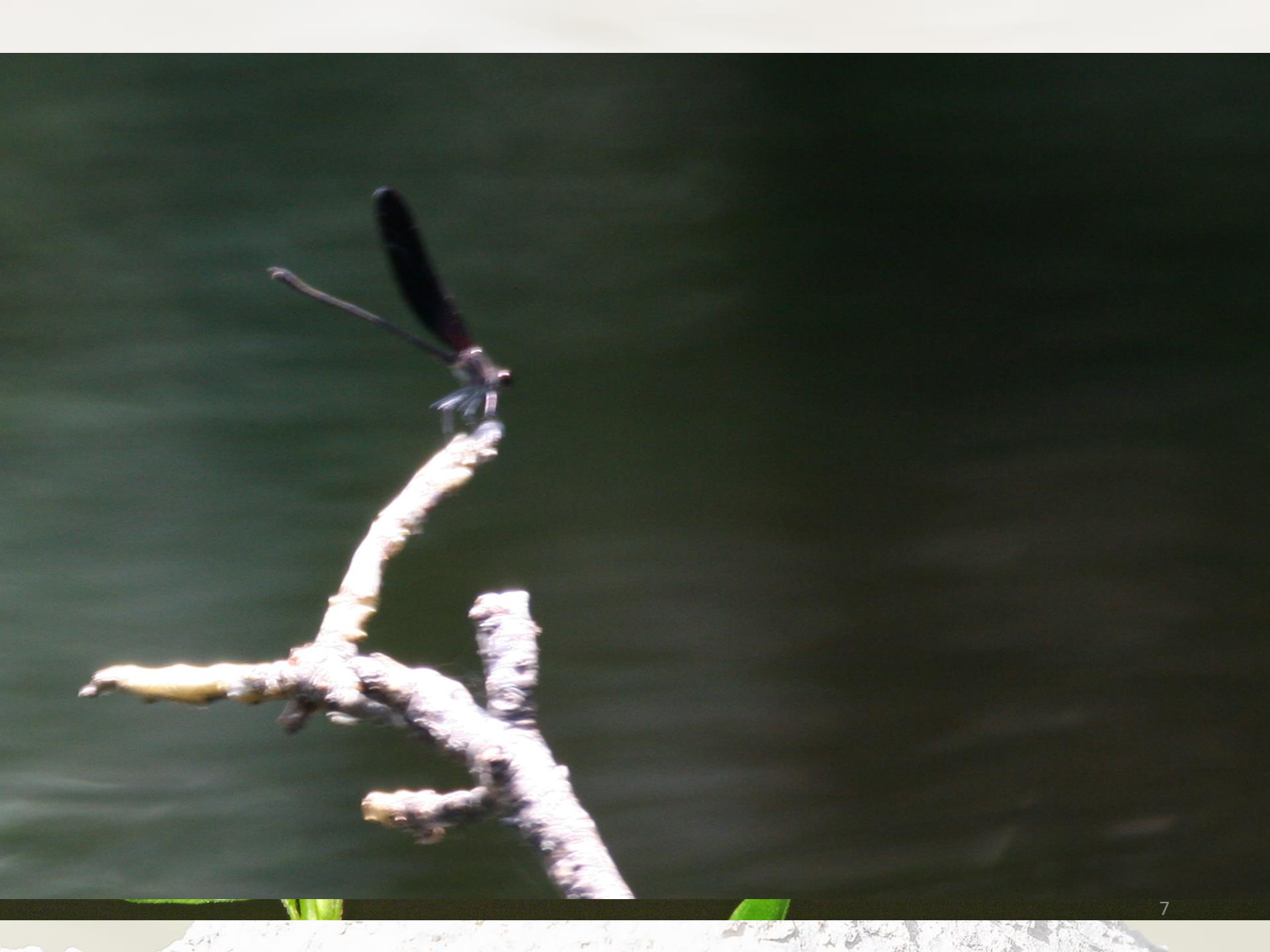


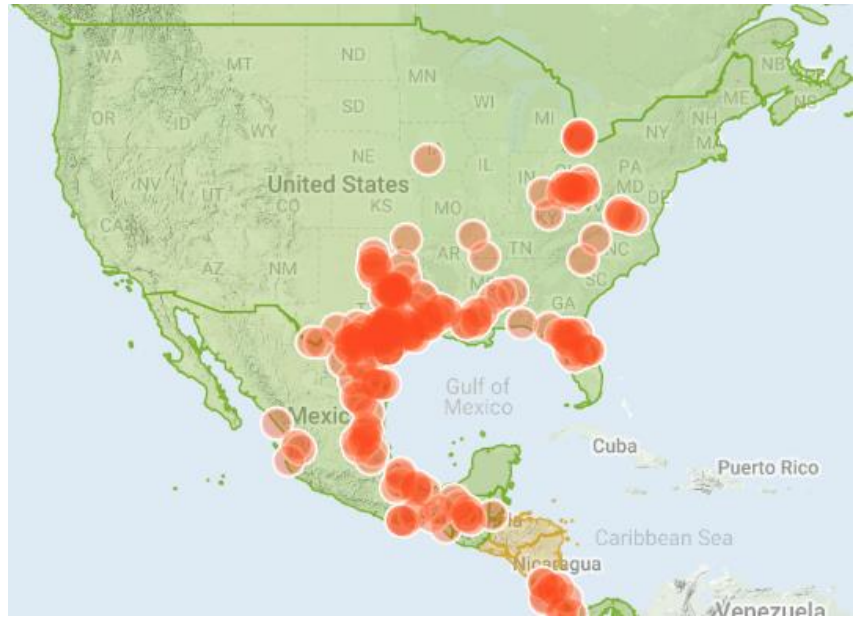
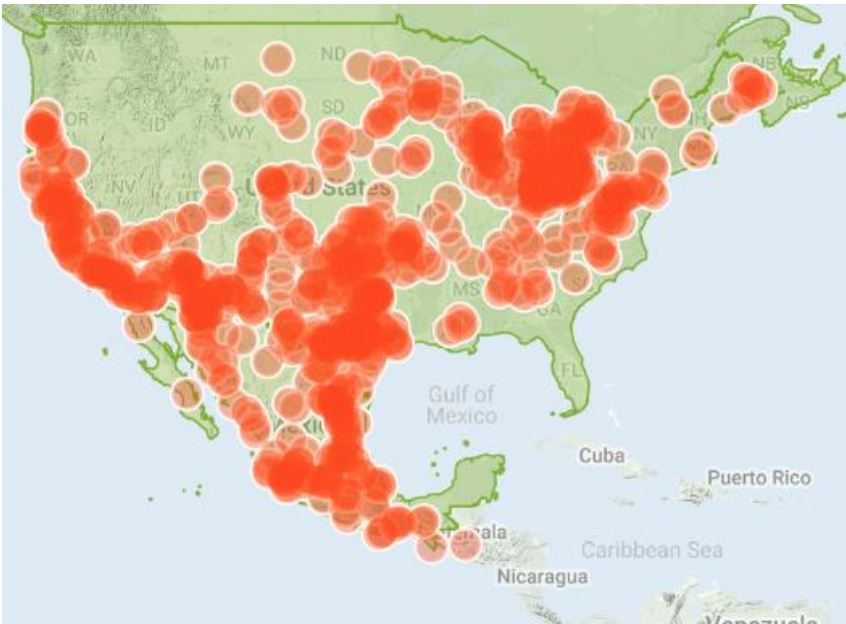






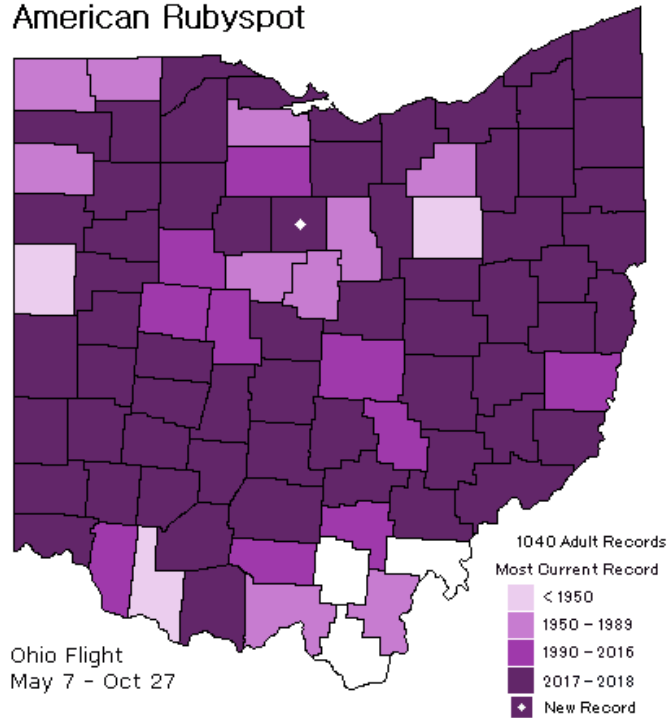
Chilled/Posed



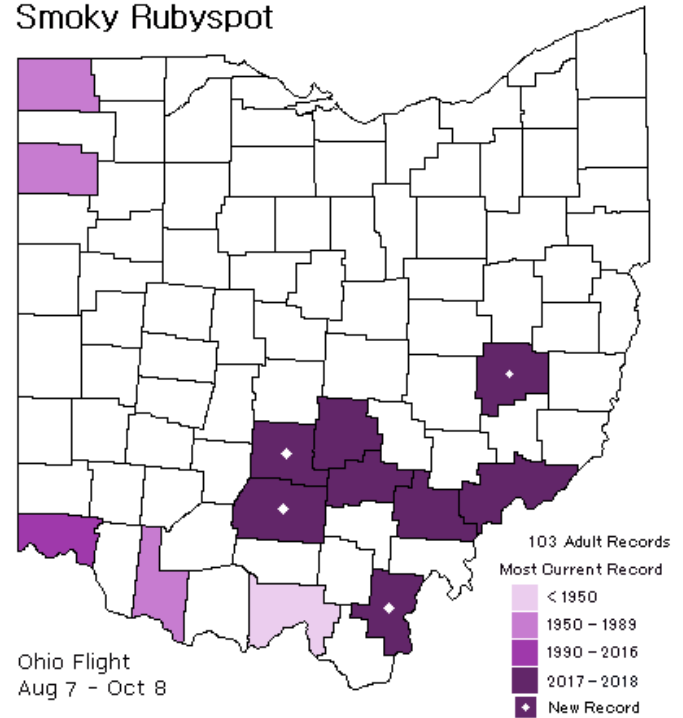




Hetaerina americana
American Rubyspot

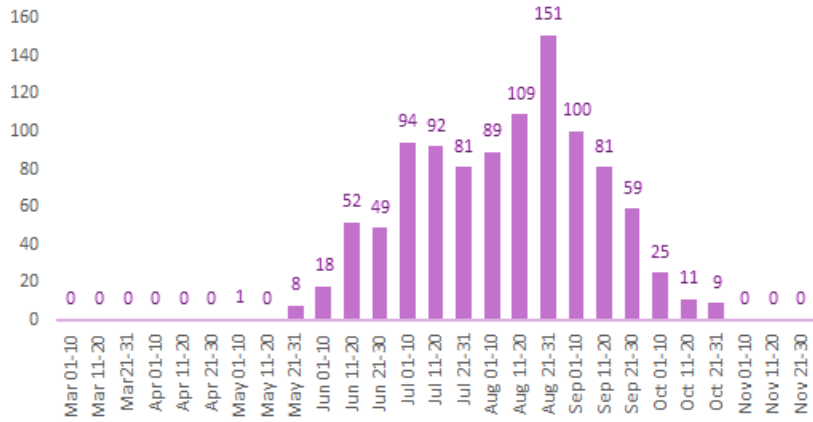


Hetaerina titia
Smoky Rubyspot



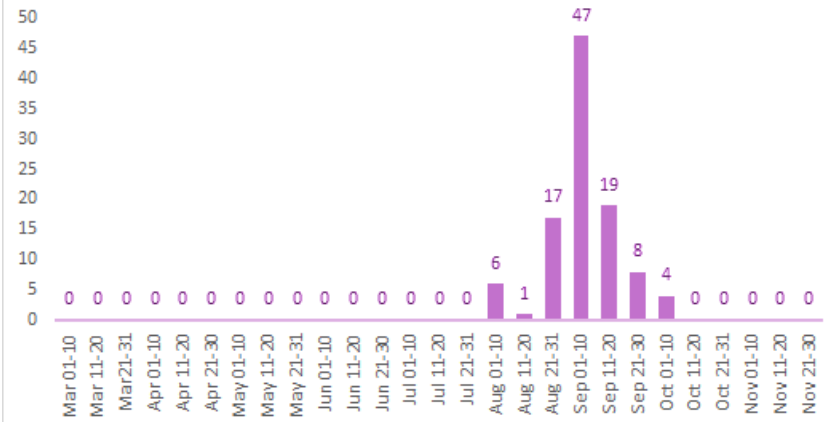


American Rubyspot - *Hetaerina americana*



OBSERVATION FREQUENCY - OHIO ODONATA SURVEY DATABASE, 2018

Smoky Rubyspot - *Hetaerina titia*



OBSERVATION FREQUENCY - OHIO ODONATA SURVEY DATABASE, 2018

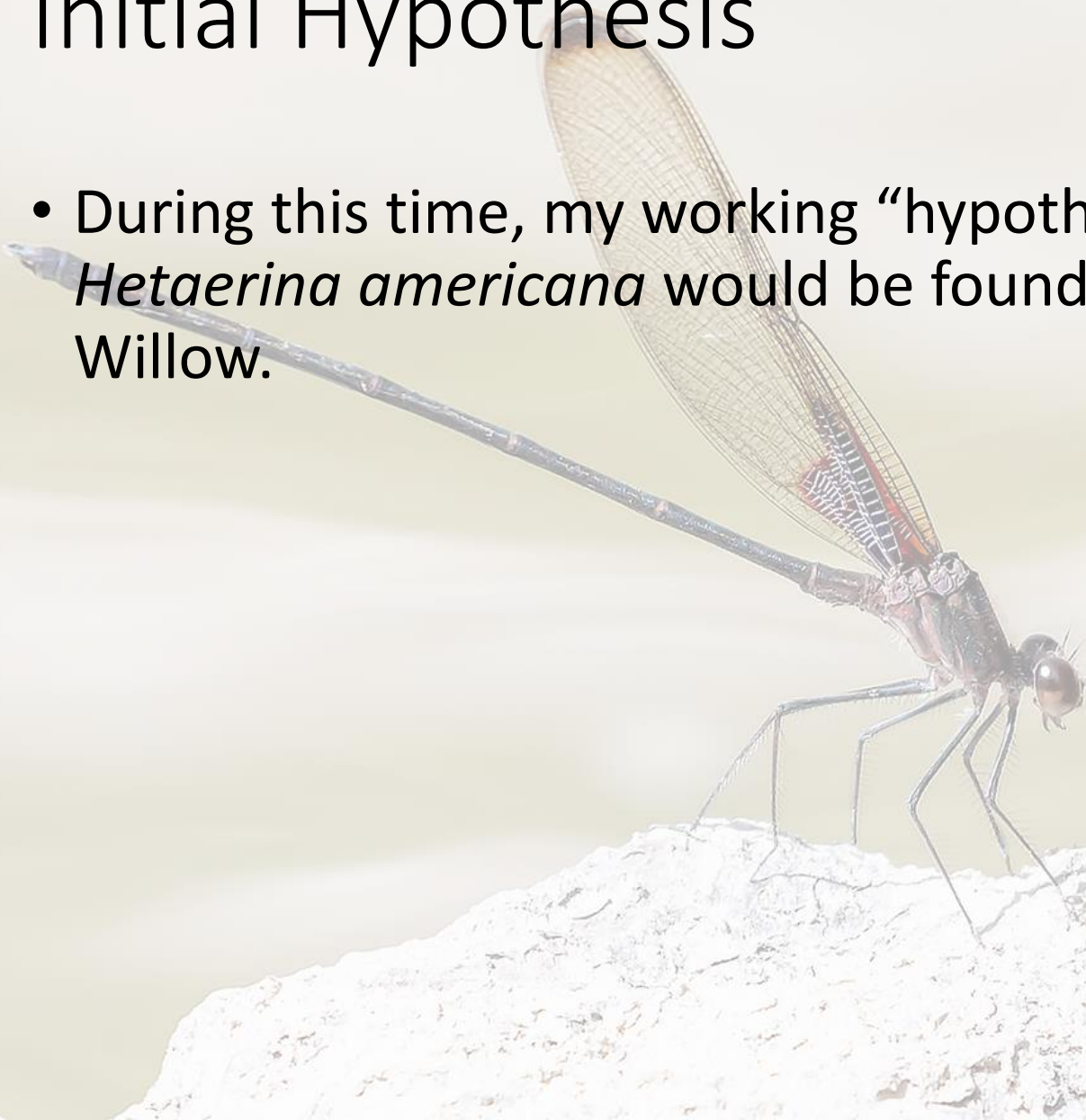
First encounters:

- Observations of *H. americana* going back to 1980
- In 1995, *H. americana* and *H. titia* collected at same site (L. Muskingum River @ Hune Bridge) by Chris Todd.
- Despite yearly surveys at that site at the appropriate time from 1995-2017 *Hetaerina titia* were only seen once or twice at that site.



Initial Hypothesis

- During this time, my working “hypothesis” was that *Hetaerina americana* would be found in Water Willow.



2017 Field Season

- *Hetaerina americana* found in usual sites, several new sites corresponding to hypothesis found.
- 1 population of *H. americana* found NOT in association with Water Willow; 1 individual found at lentic site.
- New *Hetaerina titia* population on Hocking River.
- New *Hetaerina titia* population found on Wills Creek in Byesville.

Observations:

- *Hetaerina americana* were almost always found at gravelly sites with water willow.
- The new *Hetaerina titia* sites were on streams/rivers with deeply incised, steep banks.
- The two species seem to be occupying different habitats/microhabitats.
- Question: Given that both species were found at the Hune Bridge location, how do they avoid ecological competition?

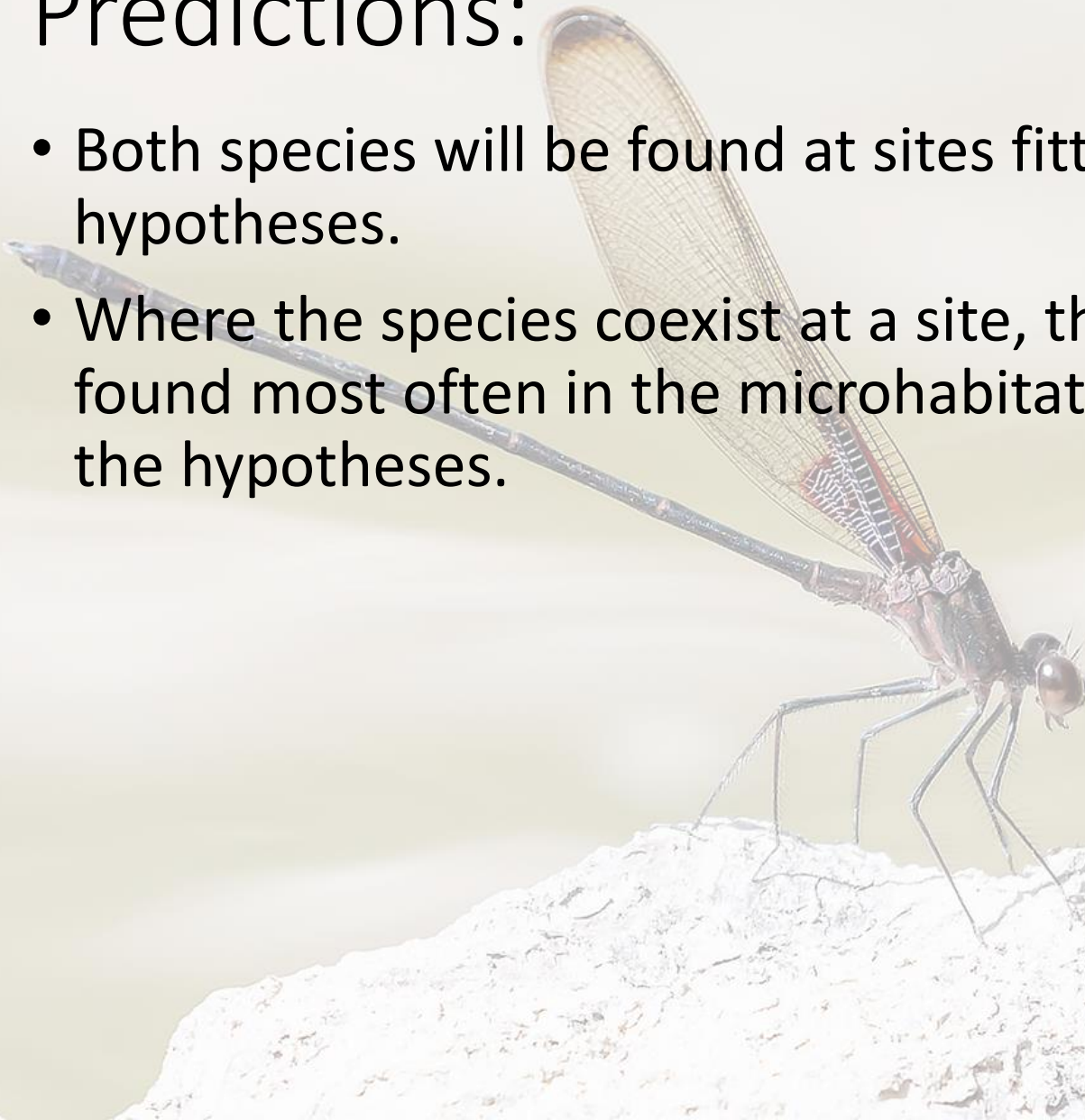
Initial Hypotheses

A damselfly is perched on a light-colored, textured rock in the foreground. The damselfly has a long, segmented body, a long abdomen, and two pairs of transparent wings with a distinct venation pattern. The background is a soft-focus view of a stream with a rocky bank and a blurred green background.

- $H_{A(2017)}$ *Hetaerina americana* males and females can be found on gravelly banks of streams and rivers in an obligate association with Water Willow (*Justicia americana*).
- $H_{T(2017)}$ *Hetaerina titia* males and females will be found at sunny sites on small rivers with deeply incised banks.

Predictions:

- Both species will be found at sites fitting with the hypotheses.
- Where the species coexist at a site, they will be found most often in the microhabitats described by the hypotheses.



2018 Observational plan:

- Continue to study sites with known populations.
- Use hypotheses to scout new potential sites in 2018.
 - Seek out additional sites consistent with the hypotheses for the two species and check for their presence/absence
- Document microhabitat use at each site.
- No attempt to be quantitative at this point.



2018 Field Season

- Hypotheses revised after discovery of new population of *H. titia* on Duck Creek at Stanleyville August 24th, 2018:
- $H_{A(2017)}$ *Hetaerina americana* males and females can be found on gravelly banks of streams and rivers in an obligate association with Water Willow (*Justicia americana*)
- $H_{A(2018)}$ *Hetaerina americana* is found in streams and rivers with gravel bars, especially gravel bars with *Justicia americana* or similar vegetation on gravel bars or along the margins, and occasionally in deeper streams. It perches primarily on sun-exposed *Justicia* or on rocks and snags in the vicinity.

2018 Field Season

- Hypotheses revised after discovery of new population of *H. titia* on Duck Creek at Stanleyville August 24th, 2018:

• $H_{T(2017)}$ *Hetaerina titia* males and females will be found at sunny sites on small rivers with deeply incised banks.

- $H_{T(2018)}$ *Hetaerina titia* prefers deeply incised rivers with deep pools where it perches on snags in the sun, either at the riverbank or mid-stream. Females prefer to perch on exposed (leafless) branches high over the water.

2018 Field Season

- Hypotheses revised after discovery of new population of *H. titia* on Duck Creek at Stanleyville August 24th, 2018:
- $H_{A+T(O)}$ When the two species coexist at a site, *H. americana* will be more likely to be perched on *Justicia americana* or similar vegetation at the shoreline and *H. titia* males will be more likely to perch on snags midstream or exposed branches on a steep bank. At a river bend, thus, *H. americana* will be on the depositional side and *H. titia* on the erosional side, as long as said location is in the sun.

2018 Field Season

- *Hetaerina americana* found in usual sites, several new sites corresponding to hypothesis found.
- *Hetaerina titia* relocated at Hune Bridge by zoology class on September 4th, 2018
- 8 new sites for *H. titia* found, most corresponding to hypothesis.
- 8 sites where both species coexist. } 11 *H. titia* sites total
- 3 sites with just *H. titia*.
- Microhabitats plotted at each site where species coexisted.

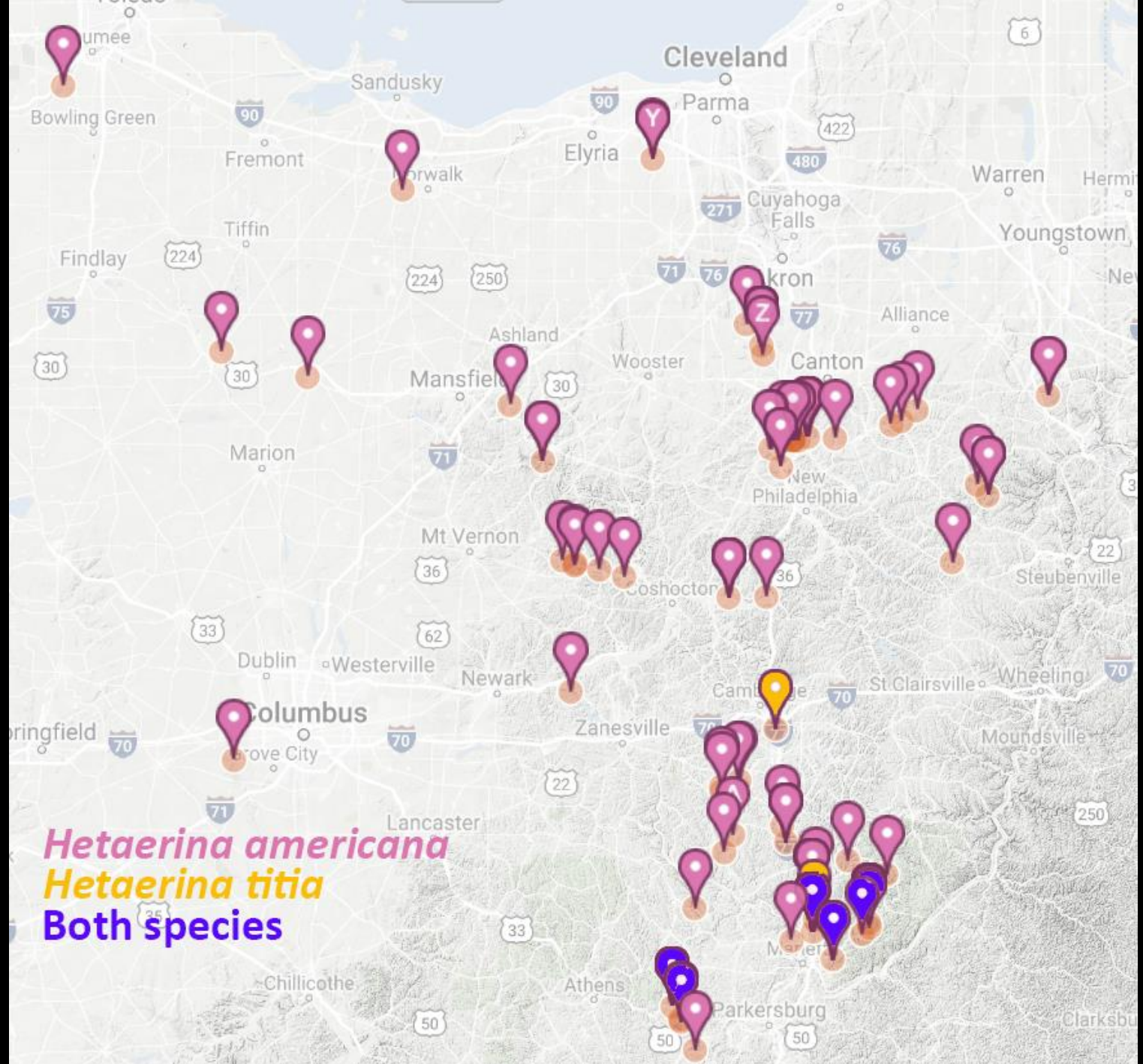


Wills Creek

Duck Creek

Little Muskingum River

Hocking River



Little Muskingum R. @ Hune Bridge, September 4th, 2018

Hetaerina titia - Smoky Rubyspot
Hetaerina americana - American Rubyspot

Little Muskingum R. @ Hune Bridge, September 4th, 2018



Hetaerina titia - Smoky Rubyspot
Hetaerina americana - American Rubyspot

Little Muskingum R. @ Hune Bridge, September 4th, 2018

Hetaerina titia - Smoky Rubyspot
Hetaerina americana - American Rubyspot

Duck Creek upstream of Stanleyville, September 7th, 2018



Hetaerina titia - Smoky Rubyspot
Hetaerina americana - American Rubyspot

Duck Creek upstream of Stanleyville, September 7th, 2018



Hetaerina titia - Smoky Rubyspot
Hetaerina americana - American Rubyspot

Hocking River, September 7th, 2018



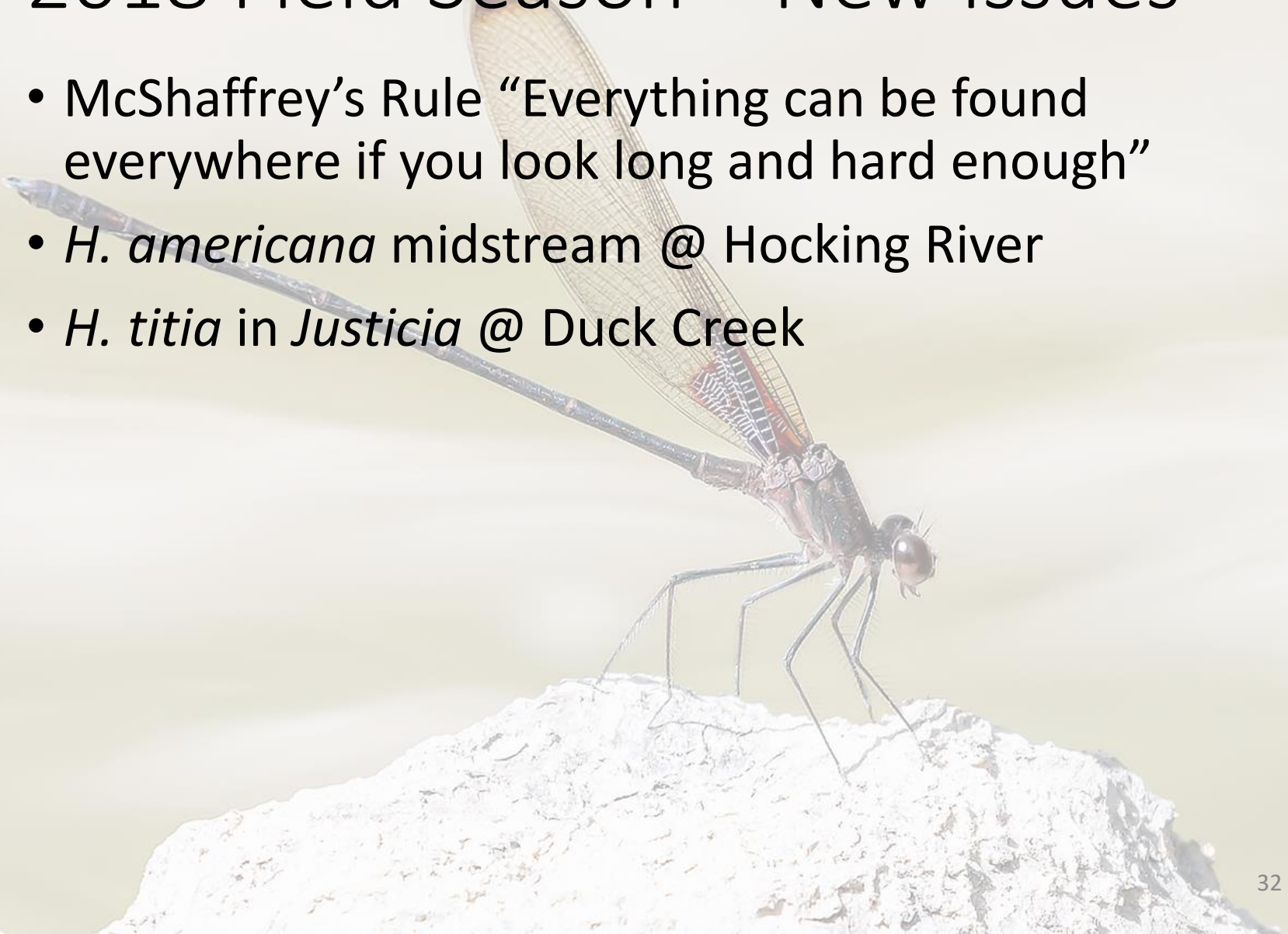
Heterina titia - Smoky Rubyspot
Heterina americana - American Rubyspot

Hocking River, September 7th, 2018



2018 Field Season – New Issues

- McShaffrey's Rule "Everything can be found everywhere if you look long and hard enough"
- *H. americana* midstream @ Hocking River
- *H. titia* in *Justicia* @ Duck Creek





Duck Creek upstream of Stanleyville, September 7th, 2018



2019 Field Season – Surprise

- *H. americana* @ Miller Creek at The Wilds 5/24/19
- Previous early record 5/7/1956
- No Water Willow at site



Conclusions

- $H_{A(2018)}$ *Hetaerina americana* is found in streams and rivers with gravel bars, especially gravel bars with *Justicia americana* or similar vegetation on gravel bars or along the margins, and occasionally in deeper streams. It perches primarily on sun-exposed *Justicia* or on rocks and snags in the vicinity.
- $H_{T(2018)}$ *Hetaerina titia* prefers deeply incised rivers with deep pools where it perches on snags in the sun, either at the riverbank or mid-stream. Females prefer to perch on exposed (leafless) branches high over the water.
- $H_{A+T(2018)}$ When the two species coexist at a site, *H. americana* will be more likely to be perched on *Justicia americana* or similar vegetation at the shoreline and *H. titia* males will be more likely to perch on snags midstream or exposed branches on a steep bank. At a river bend, thus, *H. americana* will tend to be on the depositional side and *H. titia* on the erosional side, as long as said location is in the sun.

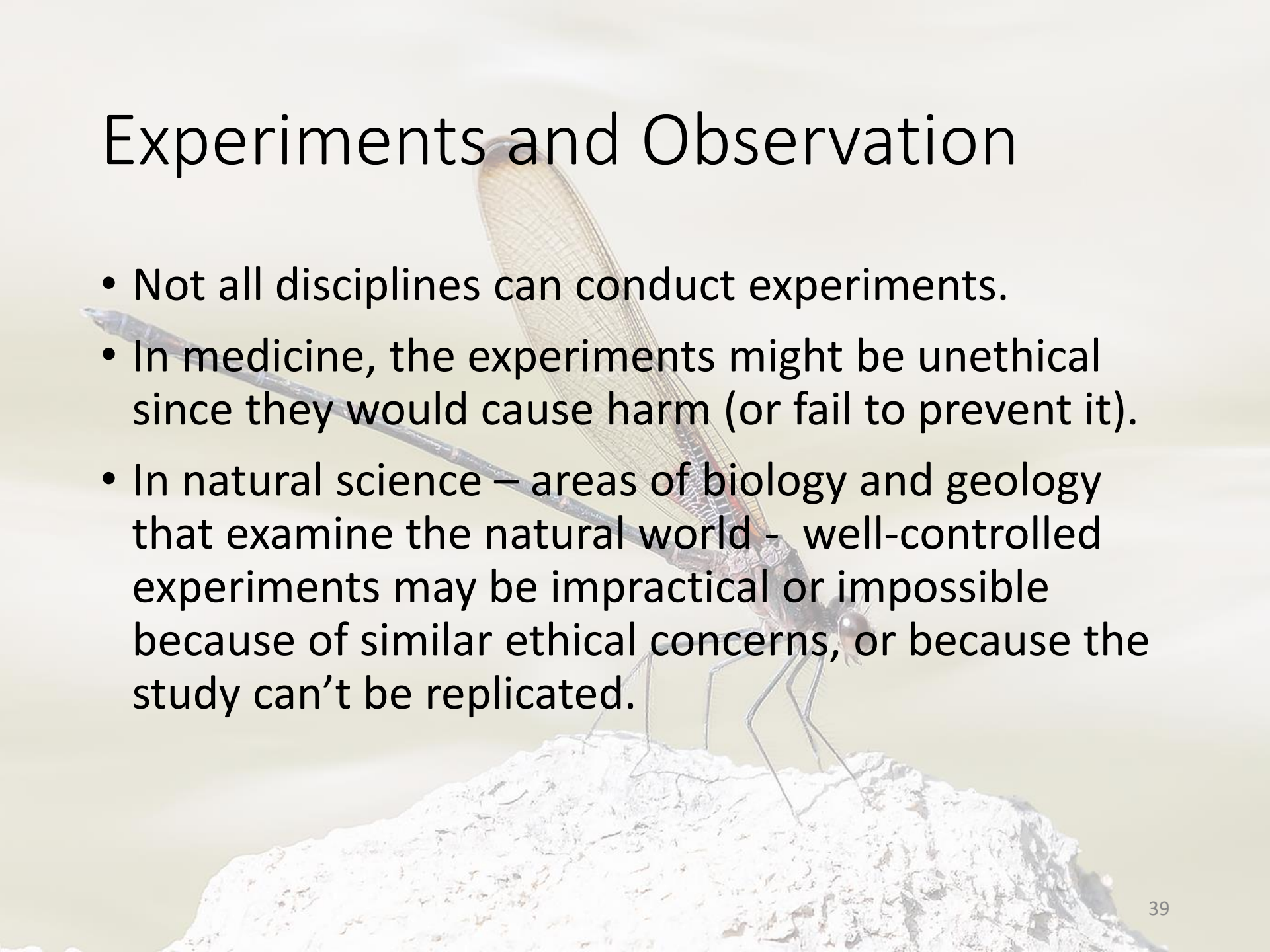
Conclusions

A damselfly is perched on a light-colored, textured rock. The damselfly has a long, segmented body, six legs, and two large, transparent wings with a distinct venation pattern. The background is a soft, out-of-focus natural setting with green foliage and a bright sky.

- Closely related species can divide the habitat at small scales so as to reduce competition for food and perching sites and help reduce the chances of interspecific pairings.
- The study of the distribution of natural populations of organisms can involve the development and testing of hypotheses.
- These hypotheses can lead to the discovery of new populations of a species.
- Whether or not the hypotheses are explicitly stated, most natural historians employ them at some level in deciding when and where to sample.
- Biases can be introduced by any internal model (hypothesis) of site preference; good citizen-scientists will be aware of these (look in some new places now and then)!




Experiments and Observation

A damselfly with a long, segmented abdomen and four large, transparent wings is perched on a light-colored, textured rock. The background is a soft, out-of-focus natural setting.

- Not all disciplines can conduct experiments.
- In medicine, the experiments might be unethical since they would cause harm (or fail to prevent it).
- In natural science – areas of biology and geology that examine the natural world - well-controlled experiments may be impractical or impossible because of similar ethical concerns, or because the study can't be replicated.

DNA example

 The basic [elements of the scientific method](#) are illustrated by the following example from the discovery of the structure of [DNA](#):

- [Question](#): Previous investigation of DNA had determined its chemical composition (the four [nucleotides](#)), the structure of each individual nucleotide, and other properties. It had been identified as the carrier of genetic information by the [Avery–MacLeod–McCarty experiment](#) in 1944,^[41] but the mechanism of how genetic information was stored in DNA was unclear.

- [Hypothesis](#): [Linus Pauling](#), [Francis Crick](#) and [James D. Watson](#) hypothesized that DNA had a helical structure.^[42]

- [Prediction](#): If DNA had a helical structure, its X-ray diffraction pattern would be X-shaped.^{[43][44]} This prediction was determined using the mathematics of the helix transform, which had been derived by Cochran, Crick and Vand^[45] (and independently by Stokes). This prediction was a mathematical construct, completely independent from the biological problem at hand.

- [Experiment](#): [Rosalind Franklin](#) crystallized pure DNA and performed [X-ray diffraction](#) to produce [photo 51](#). The results showed an X-shape.

- [Analysis](#): When Watson saw the detailed diffraction pattern, he immediately recognized it as a helix.^{[46][47]} He and Crick then produced their model, using this information along with the previously known information about DNA's composition and about molecular interactions such as [hydrogen bonds](#).^[48]

Source: Wikipedia