The Impacts of Cellulosic Biomass Production on Bee Body Size and Allometric Shape Variation

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Abstract

The Energy Independence and Security Act of 2007 mandated a 666% increase in the consumption of renewable fuels by 2022. This and other initiatives have contributed to a surge in the production of alternative fuels, generating tremendous demand for cellulosic biomass. The raw materials used in biofuel production are a preferred source of cellulosic biomass due to their ease of cultivation and rapid growth. The recent increase in grass cultivation has raised concerns about the potential impact of large-scale cellulosic biomass cultivation on native ecosystems. We investigated the impact of cultivation management strategies on the native, solitary bee, Mellisodes bimaculata. Insects were sampled from monocultures of switchgrass, Panicum virgatum, and loblolly pine, Pinus taeda, as well as plots managed as switchgrass/pine intercrops. These cultivation management strategies provide differing spatial and temporal availability of bee forage. The availability of food resources has previously been demonstrated to impact insect allometric shape variation and, in turn, insect flight performance. In this study, we examined anatomical metrics of Mellisodes bimaculata within the three treatment groups.

EPI – What is it, why do we care?

The excess power index, or EPI, is a measure of the maximum power available to a bee over the power to maintain equilibrium in steady level flight. The equation is as follows:

\[
EPI = \frac{r \cdot W}{W} = \frac{\text{thoracic mass/body mass ration}}{W = \text{wing loading}}
\]

The thorax of the bee is suggested to be its “flight engine”

Can bee morphology, and consequently, flight capability, be influenced by differing types of cultivation management strategies?

Bee Anatomy

Wings are photographed

Wings are removed, mounted

Wings are dried and weighed with and without legs

Thoracies are photographed

Wings, as well as thoracies, are analyzed using TPSdig2

Bee Development

Once a bee exits the larval stage and enters adulthood, growth can no longer occur. Therefore, the nutrients and resources obtained during the larval stage are the determinants of adult size.

Experimental Design

• The study site was located in Mississippi.
• 16 study plots (~25 acres each) comprising 4 treatments were utilized. Treatments included:
  1. Switchgrass + young pine (Young pine; St)
  2. Switchgrass + mature pine (Old pine/St)
  3. Young pine only (Young pine)
  4. Mature pine only (Young pine)
• Our samples were collected using colored bowl traps.
• Insects were sampled seven times from May-August 2013 and eight times from May-August 2014. Sampling occurred in 72 hour increments.

Data

Treatment

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Switchgrass</th>
<th>Young pine</th>
<th>Mature pine</th>
<th>Mature pine + switchgrass</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AB</td>
<td>AB</td>
<td>B</td>
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</tbody>
</table>

Conclusions

Though there are differences seen within the treatment groups, there are many variables that make any concrete conclusions difficult to draw. This includes plant diversity within the treatment groups. However, significant differences can be seen between males and females. Though the females possess larger measurements in nearly all the allometric variables, males possess a greater excess power index. This means that they have stronger flight capabilities. This could be due to the solitary nature of this species and, consequently, the need to fly greater distances to mate and forage.

Future Directions

Our future plans for this project include expanding the types of treatments, as well as producing data for different species of bees and other insects. We hope to investigate whether the sexual dimorphism identified expands to other species.

Acknowledgements

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References