An assessment of crop yield dependence on insect pollination services in the neotropics

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*Trigonisca buyssoni* on papaya flower
The pollination service

- Large contribution to food production
- Suggested that more than 90% of 250,000 species of modern angiosperms and 65% of all plant species are pollinated by animals
The pollination problem

- Global pollination crisis
- Scarcity of pollination data globally
- Large proportion of crop value due to pollination – but largely unrecognised
- Global shift to animal pollinated crops
- Nutrition shortage
The value of pollination

- Range of valuation techniques
- Global pollination value estimated at €153 billion
- The estimated Insect Pollination Economic Value (IPEV) for the Caribbean and Latin America is $3.5 \times 10^9$ Euros (Gallai et al. 2009)
- Morse and Calderone (2000) used a simple function to assess the value of US honeybees: $V \times D \times P$

*Megachile lanata* on cucumber flower
Main local issues

- Neglected agricultural sector
- Virtually no local or regional data on pollination, only anecdotal
- No standardised assessment methods available
- Pollination not accounted for and vastly undervalued regionally
Objectives

- to provide simple order of magnitude valuations for selected pollination services in Trinidad
- to demonstrate the value of pollination services to farmers in a tropical wetland and the subsequent loss due to a reduction in pollination services

*Trigona amalthea* on pumpkin flower
Context

- Pollinator identification
- Pollinator management
- Pollinator visitation patterns
- Pollination valuation

Stakeholder knowledge, management tools

Crop pollinators in neotropical agricultural landscapes – stocktaking of important species

Crop pollinators in neotropical value of pollination – effects of pollinator absences

Pollinator visitation patterns in agricultural fields – abiotic effects on the service
What are local pollination services worth?
Construction of exclusion enclosures

Tagging and bagging of flowers in various enclosure types (cucumbers and hot peppers)

Establishment of four farmer plots

Determination of dependence

Observation of development and harvest

Exomalopsis sp
Percentage of tagged cucumber flowers developed into fruits under each exclusion condition ($H = 8.748, 3$ df, $p = 0.033$)

Percentage of tagged hot pepper flowers developed into fruits under each exclusion condition ($H = 9.993, 3$ df, $p = 0.019$)
Percentage of the additional contribution made by each subsequent (larger) exclusion type for cucumbers

Cucumbers
- The largest contribution is made by the ¼ inch exclusion
- smallest insect group makes the largest contribution to cucumber pollination

Hot peppers
- The largest contributions made by ¼ and ¾ inch exclusions
- yield was higher in ¾ inch enclosures than open enclosures
- insects able to access ¾ inch enclosures were considered to make the final contribution to production
- no extra value added by insects only able to access open enclosures
Loss of income in complete absence of pollinators

<table>
<thead>
<tr>
<th>Crop</th>
<th>Mean % reduction in yield</th>
<th>Yield</th>
<th>Approximate yield per acre</th>
<th>Wholesale price (US$)</th>
<th>Approximate loss per acre (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot peppers</td>
<td>88.1</td>
<td>0.54 to 7.25</td>
<td>1,456 to 19,553</td>
<td>5.55 per 100</td>
<td>71 to 956 per week</td>
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<tr>
<td></td>
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<td>peppers per plant per week</td>
<td>peppers per week</td>
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<tr>
<td>Cucumbers</td>
<td>96.5</td>
<td>646g/m² to 3492g/m²</td>
<td>2,614.27 kg to 14,131.64 kg per crop</td>
<td>0.9 per kg</td>
<td>2,270 to 12,273 per crop cycle</td>
</tr>
<tr>
<td>Ochro/okra/gumbo</td>
<td>86.2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Prices listed for crops during time experiments were conducted (NAMDEVCO 2007). All prices shown in US$ converted using exchange rate: US$1 = TT$6.4.
### Differences in weekly income from hot pepper harvests based on location

<table>
<thead>
<tr>
<th>Location</th>
<th>Weekly harvest per plant (number of hot peppers)</th>
<th>Weekly income per plant</th>
<th>Weekly income per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site S</td>
<td>7.25</td>
<td>0.54</td>
<td>1,467.24</td>
</tr>
<tr>
<td>Site K</td>
<td>5.28</td>
<td>0.40</td>
<td>1,067.96</td>
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<tr>
<td>Site F</td>
<td>0.54</td>
<td>0.04</td>
<td>109.94</td>
</tr>
</tbody>
</table>

- A difference was observed between locations ($H = 11.526$, 2 d.f., $p = 0.03$).
- Importance of landscape in pollination supply
- No difference was determined between the average number of flowers produced per location ($H = 1.201$, 2 d.f., $p = 0.549$) or enclosure type ($H = 1.268$, 2 d.f., $p = 0.531$)
National loss (cucumbers): 1,326,370kg; TT$7,653,156 (US$1,195,806)

Loss of TT$6,275,587.71 (US$980,560) for 2012 for sales from this market alone

NAMDEVCO: 1,127,071 kg sold in 2012 at Norris Deonarine Market

CARDI: 82% grown in Trinidad sold via this market

Complete pollinator absence: Reduction to 39,447.48 kg
Upscaling: Hot peppers

NAMDEVCO: 24,690 sets of 100 sold in 2013 at Norris Deonarine Market

Complete pollinator absence: Reduction to 5,703 sets of 100 peppers

Loss of TT$674,418.24 (US$105,378) (2013) for sales from this market alone
• In cucumbers, the smallest size group of pollinators appears to make the largest contribution, which notably excludes *Apis mellifera*

• Hot pepper pollination seems to be equally supported by small and medium sized insects

• Higher dependency of all three crops than cited in previously published literature
• Results contradict Morse and Calderone’s estimates (cucumber dependence on Apis mellifera - 0.9)

• In absence of smaller pollinators, *Apis* bees may provide a buffer and make up for the lack of other pollinators
What can we do?
Given the high dependency on insect pollinators, national initiatives should focus on the education of farmers, including the need for pollinator conservation and the use of sustainable farming practices, and the formulation of policies to protect and manage pollination services.
Precautionary Principle
<table>
<thead>
<tr>
<th>Private citizens</th>
<th>Farmers</th>
<th>Researchers</th>
<th>Government</th>
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<tbody>
<tr>
<td></td>
<td>Plant flowers</td>
<td>Observe and record insects!</td>
<td>Pollinator surveys</td>
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<td></td>
<td>Start kitchen gardens</td>
<td>Multicropping</td>
<td>Further investigation of effects of landscape, abiotic conditions, pesticide effects on pollination provision</td>
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<td>Provide pollinator habitat</td>
<td>Plant non-crop flowers in between crops</td>
<td>Lobbying – decreasing gap between science and policy</td>
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<td>Spraying: low wind, high temperature, low dew conditions</td>
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<td>Plant hedgerows</td>
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<td>Provide pollinator habitat – nest boxes, bare ground, wooden stacks</td>
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<td>Use alternative pest control methods</td>
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<td>Leave portion of land unplanted</td>
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<td>Farmer education initiatives</td>
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<td>General population education initiatives</td>
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<td>Restriction of pesticide use</td>
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<td>Subsidies for pollinator friendly farms</td>
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<td>Development of pollination strategy and policy</td>
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<td>Pollination surveying and monitoring</td>
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Conclusions

- Apis bees do not provide the bulk of pollination services for the assessed crops
- Dependencies ratios were found to be higher than previously estimated
- Insects less than ¼” in diameter provide crucial pollination services
- Farmer education initiatives and policy development needed to safeguard service
Thank you!