An Initial Survey of the Relationship between Figs and Fig Wasps on the Island of Dominica, W.I.

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Abstract

Fig wasps are highly specialized inhabitants of several species of Ficus. By looking at the generalized biology and the specialization of these wasps, we plan to determine the species of an unknown tree by comparing its data to the data of known species. Our findings tend to challenge some previously thought ideas and verify nature's ability to allow for transition.

Introduction

Fig wasps (Hymenoptera: Agaonidae) belong to the superfamily Chalcidoidea. About 640 species of fig wasps have been described in the world (http://www.figweb.org). The generalized life cycle of a pollinator fig wasp begins when the first mature female wasp flies into the ostiole of a receptive fig and lays her eggs in the gall flowers. After the male eggs hatch, which are laid first in the sequence, they mate with the females and chew an escape route for their mates. The males then die and the females go on to new figs and continue this cycle. (Ramirez, 1970). In New World fig wasps, agaonids appear to have a 1:1 correlation with their host trees. Each species of Agaonidae seems to pollinate only one specific species of *Ficus*, and rarely, a fig of similar shape and size will be pollinated by a close relative of its own pollinator. (Boucek, 1993). Agaonidae are the only method of pollination for Ficus (Ramirez, 1988). Due to this monopoly, specialization in wasps occurs all the way down to the species level. This specialization leads to striking adaptations in the morphology of these wasps. Depending on the ostular opening, they may have modified mandibles or head shape. Only some members of Agaonidae are pollinators, and there are several other fig wasps which are parasites of either the synconia of the fig gall formers or of other agaonids in the fig. (Ramirez, 1974). Agaonid females are winged and have pollen carrying structures, a long ovipositor to help lay eggs in female flowers of *Ficus*, and to help them enter the ostiolum of the flower. Male agaonids are not winged and usually never leave the host fig, where as females often escape the fig (Ramirez, 1974).

The figs in Dominica belong to the family Moraceae, which contains the genera *Artocarpus, Cercopia,* and *Ficus.* These genera produce breadfruit, small flowers, and highly specialized figs, respectively. The *Ficus* species that we encountered were *F. insipidia*, *F. citrofolia*, and one unknown species of *Ficus*. Both of the known species of *Ficus* that we encountered belong to the subgenus and section *Pharmacosycea.* The *Ficus citrifolia* is about 16 meters in height, has aerial roots, figs are found in pairs on the stalks, and are found mostly in the lowlands of Dominica (Lack, Whitefoord, Evans, James, 1997). The *Ficus insipida* does not have aerial roots and the figs are found solitarily on the stalks (Lack, Whitefoord, Evans, James, 1997). The unknown species that we found possessed aerial roots and was in the process of taking over an unknown species of tree in the Botanic Gardens, Roseau. By using the characteristics and the biology of the fig wasps and *Ficus* species, we hoped to determine the identity of the unknown tree.

Materials and Methods

We collected figs from three different fig trees from May to June 2007. The first tree was located at 15 □ 20.720N, 061 □ 22.084W near Checkhall River on Archbold Tropical Research and Education Center (ATREC). We determined this tree to be *Ficus insipida*. We also collected from *Ficus citrifolia* on the Mango Trail (15 □ 21.001N, 061 □ 21.957W**)** and an unknown strangler fig (15 □ 17.905N, 061 □ 22.762W). We collected figs into one gallon Hefty Ziploc bags and transported them to ATREC where we used a razor blade to open them and a microscope to look for specimens. When we found them, we then used fine forceps to pull them out and place them in vials with 95% ethanol for later identification. We separated the wasps into vials based on their host fig. We then sorted the vials according to the tree that they came from. Next, we went through and found ideal specimens from each tree and Dr. James Braden Woolley took photographs of them using a Nikon D1X 60mm macro lens and 110mm of lens extension. We also set several figs aside and attempted to rear wasps using three different apparatuses. Our goal was to allow air flow to the figs to prevent molding. We designed a container using a one gallon bag with 6 inch holes cut in the center covered by mesh to keep wasps from escaping. We made 3 of these bags in which we placed several of the figs. We also designed a container using a 50mL plastic vial with a mesh center in place of the plastic. Last, we simply placed three or four paper towels into a Ziploc bag with the figs and sealed the bag. All of these containers were unsuccessful and we only succeeded in growing mold on all of the figs. We used Boucek's key to the genera of chalcidoid wasps to identify our collected specimens with help from Drs. James Woolley and Robert Wharton. After identification, we used Microsoft Excel to store the data.

Results

Table 1. Summary of Fig Dimensions and Number of Wasps Collected from Each Species of Fig.

Fig Species	Average Diameter (mm)	Average Petiole Length (mm)	Average Number of Wasps per fig	Average Number of Males per fig	Average Number of Females per fig	Average Number of Pollinators per fig
F. citrifolia	**9.000**	**3.833**	**1.333**	**0**	**1.333**	**1.333**
F. insipida	**29.250**	**11.875**	**2**	**0.375**	**2.250**	**2.375**
Unknown Ficus sp.	**13.517**	**0**	**1.100**	**0.033**	**1.000**	**1.033**

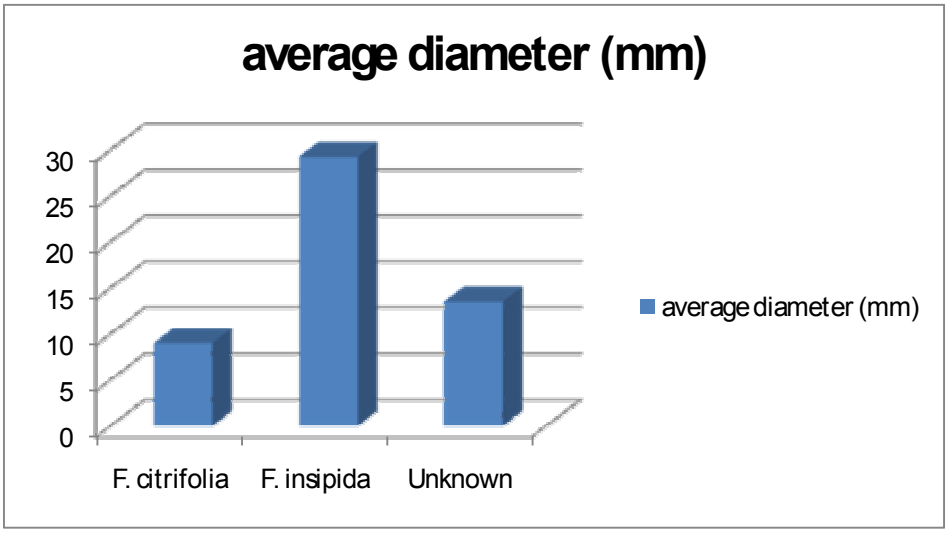

Figure 1. Average Diameter of Figs from Three Species of *Ficus*.

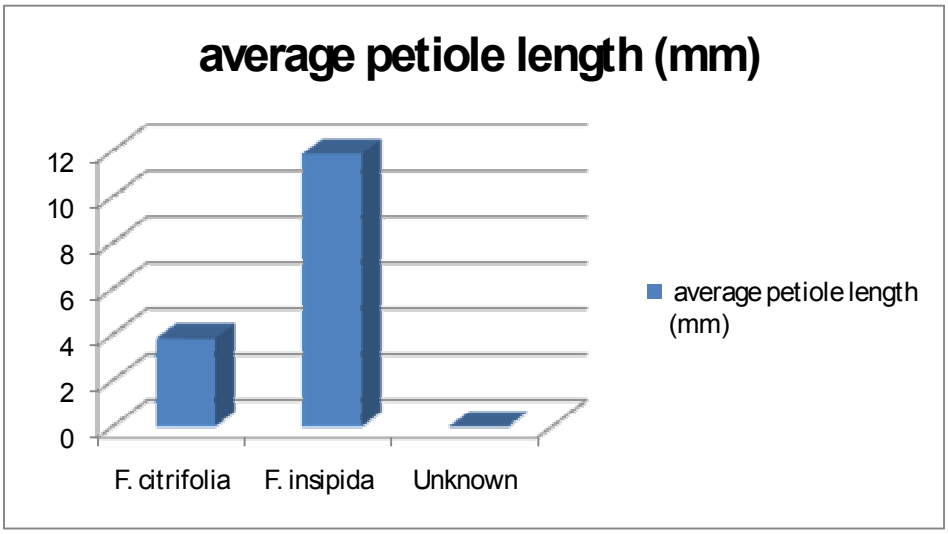

Figure 2. Average Petiole Length of Figs from Three Species of *Ficus*.

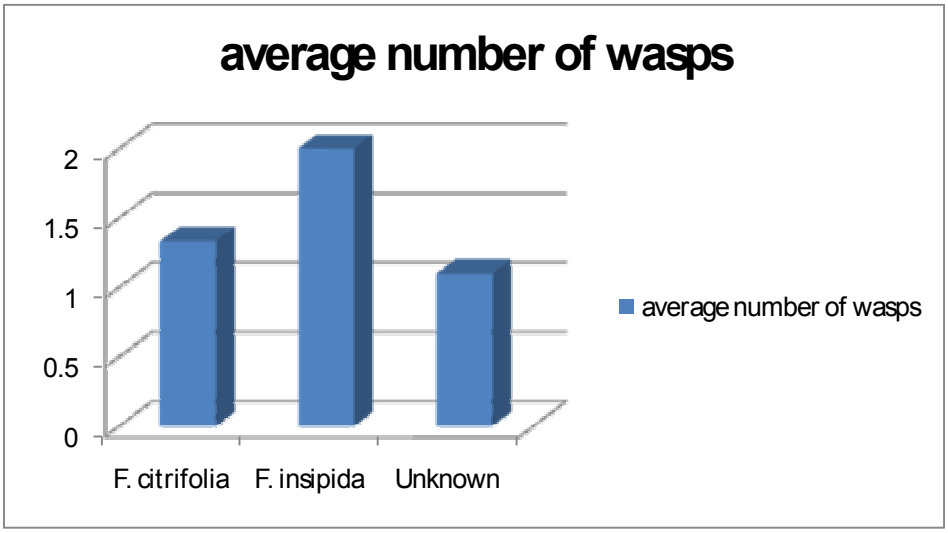

Figure 3. Average Number of Wasps Collected from Figs of Three Different Species of *Ficus*.

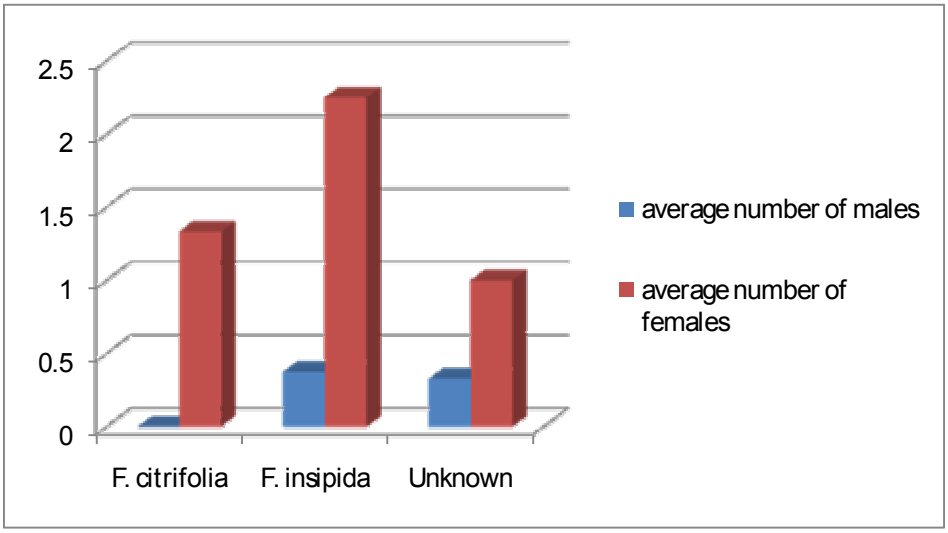

Figure 4. Average Number of Males and Females Collected from Figs of Three Different Species of *Ficus*.

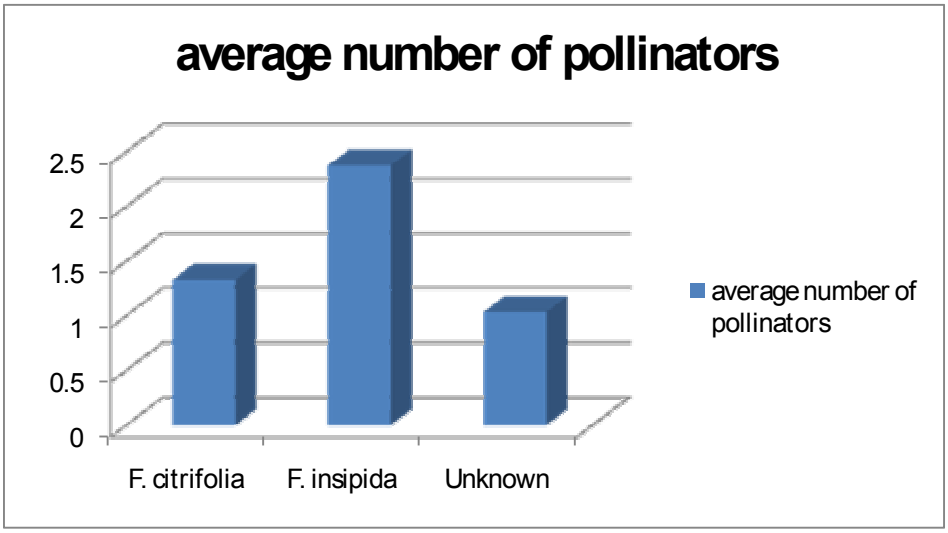

Figure 5. Average Number of Pollinators Found in Figs from Three Different Species of *Ficus*.

We used Boucek's key to identify the wasp genera *Critogaster* and *Tetrapus*. The characteristics that he used to describe *Critogaster* are "Notauli deep, percurrent. Stigmal vein shorter than one third the length of marginal vein. Males alate or apterous" (Boucek). The characteristics that he used to describe *Tetrapus* are "Mandibular appendage with its outer and inner appendages saw like, with a row of distinct teeth. Antennal flagellum filiform, appearing bare, longitudinal sensilla not raised above surface. Forewing veination partly reduced, stigmal vein missing. Body length over 2mm"(Boucek, 1993).

In *F. insipida,* we found six *Tetrapus* pollinators and twelve *Critogaster* gall formers inside eight total figs. There were two *Critogaster* males found, one of which was an unknown male species, and 18 female *Tetrapus* pollinators. *Critogaster* was the most common genus of wasps collected in *F. insipida*. In *F. citrifolia*, we found four female *Tetrapus* pollinators and no males in 3 different figs. We found no gall formers in any of these figs. In the unknown *Ficus* species, we found one male *Tetrapus* pollinator and 29 female *Tetrapus* pollinators in 32 different figs.

Discussion

There are three types of flowers within the synconia of each fig: female flowers that often set seeds, male flowers, and gall flowers, where Agaonids usually oviposit (Ramirez, 1974). We collected figs in all three stages of development from each of the three trees. Many figs we found were in the prefloral phase (Ramirez, 1974), and we found no wasps in this stage. We also collected many figs in the "female phase" in which we discovered most of our specimens (the majority of which were pollinators). We drew this conclusion based on the facts that this is the point in time that the figs are most receptive to oviposition and pollination by the wasps.

According to Ramirez, all agaonids except those in the genus *Tetrapus* break their wings and antennae upon entrance into the ostiole (Ramirez, 1974). We did not find this to be the case, since we found several instances of females in this genus with both antenna and wings missing.

After reviewing the results, we have noticed a strong correlation between the *F. citrifolia* and the unknown tree at the Botanic Gardens. The average diameter of the figs from the unknown tree was larger than the average diameter of the figs from *F. citrifolia*, but they were much smaller than the average diameter of figs from *F. insipida* (Table 1). However we did find a fig that appeared to belong to the species *insipida* around the same tree. This leads us to believe that the *citrifolia* is using the *insipida* as a host, and that these two trees are in a stage of transition from *insipida* to *citrifolia*.

In order to verify these findings, this experiment needs to be replicated several times to monitor the progress of this transition. It would also be ideal to use the newfound knowledge that we possess on rearing insects to see what possible wasps and/or parasites might to come out of these figs.

Figure 6: *Critogaster* sp. #1

Figure 7: *Critogaster* sp. #1

Figure 8: *Critogaster* sp. #2

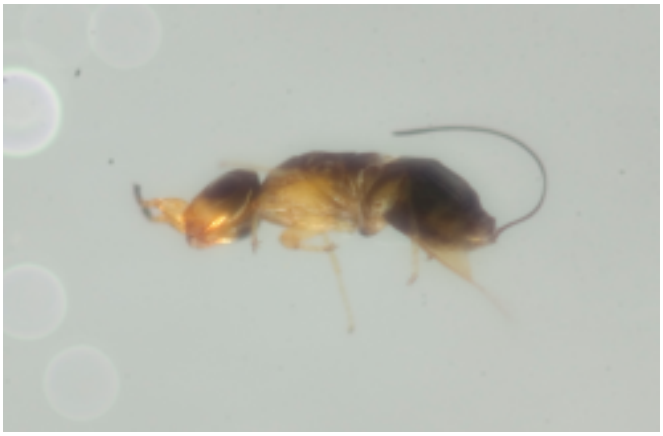

Figure 9: *Tetrapus* sp.

Figure 10: *Tetrapus* sp. male

Figure 11: Unidentified male

Acknowledgements

We would like to first and foremost thank Drs. James Braden Woolley and Robert Alan Wharton for their considerable time and effort devoted to this project and to helping us identify our wasps. We would also like to thank Ms. Nancy Osler for allowing us to inhabit ATREC for 3 weeks and providing us a relaxing environment in which to do our work, Mr. Elvis Stedman for helping us to identify our fig trees, and finally Mr. Lloyd Winston Towers III for his time in helping us collect numerous figs.

References

Boucek, Z. (1993). The genera of chalcidoid wasps from *Ficus* fruit in the new world. Journal of Natural History, 27: 173-217.

Lack, Andrew J., Caroline Whitefoord, Peter G. Evans, and Arlington James. Dominica Nature Island of the Caribbean. 1st ed. Roseau, Common Wealth of Dominica: Ministry of Tourism, 1997. 49.

Ramirez, William B. (1969). Fig Wasps: Mechanisms of Pollen Transfer. Science, 163: 580-81.

Ramirez, William B. (1974). Coevoution of Ficus and Agaonidae. Annals of the Missouri Botanical Garden, 61: 770-80.

Ramirez, William B. (1988). Parasitic Relationships Among Chalcidoid Fig-Wasps and the Syconia of Ficus (Hymenoptera: Chalchidoidea). Advances in Parasitic Hymenoptera Research, 345-50.

"Fig Wasp Diversity." http://www.figweb.org. Iziko Museum of Cape Town. 10 June 2007 <http://www.figweb.org>.