

Tiny and Annoying: Diptera Population Composition in the Forests of Mo'orea

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Abstract. Plant composition is well documented as affecting the corresponding insect community. Invasive plants have been recorded as causing changes in insect populations, usually through the depletion of phytophagous insects. However, few studies have addressed how non-herbivorous insects are affected by the presence of invasive plants. This research sought to adapt more general plant-invasive studies in two ways: One, to collect Diptera, an order known to exist at multiple trophic levels and two, to choose field sites along the Three Pines Trail, located on the island of Mo'orea (French Polynesia). Diptera were collected using Malaise traps and identified to family. Using a one-way ANOVA test, it was determined that there were no significant differences among site types for Diptera population composition or for biomass. Significant differences were found for family abundance between invasive and naturalized sites. Potentially, Diptera are not affected by plant composition because many are not herbivorous or they have already adapted to invasive plant resources.

Key words: Arthropods, Insects, Diptera, Invasive plants, population composition

INTRODUCTION

As a primary food source, the quality and composition of plant communities is one of the greatest variables of corresponding insect populations. Extensive research has been conducted comparing how insects affect plant population dynamics (Crawley 1989) as well as how plant community composition affects insect populations (Price et al. 1980). Most studies focused on herbivorous insects as the immediate predators of plants. These studies have discussed a variety of plant-insect interactions, including plant chemical defenses (Fraenkel 1959), co-evolution between the two groups (Feeny, 1975), and correlation between diversity and biomass (Murdoch et al. 1972). Outside of insect herbivory, studies were also conducted on the interactions between pollinators and other mutualistic insect-plant relations (Bronstein et al., 2006).

Within plant-insect interaction research, there have been studies focused on the impact invasive plants have on insect populations. With the relatively recent increase of exotic plant imports, researchers are able to catalogue the ecological disparities that result from these introductions (Cox 1999). Once again, most of these studies are specific to the phytophagous insects, but the results are contradictory. The research generally focuses on testing the Enemy Release Hypothesis, a theory suggesting that alien plants will suffer less attack in a new region lacking their usual

predators (Keane and Crawley, 2002). Most short-term studies supported this theory, as in a 2005 paper that sampled in-situ leaf herbivory patterns (Cappucino and Carpenter 2005). However, other studies found no difference in herbivore loads between invasive and non-invasive plants, although this might have been due in part because of the phylogenetic similarity between the alien and native plants (Frenzel and Brandl 2003). Outside of the possibility of phylogenetic similarity, others suggested that herbivorous insects rapidly evolved to accommodate alien sources of food (Siemann et al., 2006).

But how do these studies apply to insects that are not directly feeding on plants? A 1993 study showed that the usually host-specific butterfly, *Euphydryas editha* was able to incorporate invasive plants into its diet in less than a decade (Singer et al. 1993). Another pollinator based study sought to answer if insects that did actually pollinate invasive plants were generalists and found that *both* generalist and non-generalist pollinators visited invasive plants and that diversity levels were the same between the two plant categories (Bartomeus et al. 2007). Clearly, the application of the Enemy Release Hypothesis is somewhat less reliable in insects that are not strictly phytophagous.

The methods used for conducting these broad insect biodiversity studies can sufficiently be adapted for looking at diversity within orders or other functional group

categories. Furthermore, it makes sense to apply these studies to habitats like the forested regions of Mo'orea, which are becoming overrun with *Miconia calvescens* and other invasive plants (Meyers 1996). Certainly, studies have been conducted looking at the impact invasive insects have on native plants, especially on other Pacific islands like Hawai'i (Bryan 1933) and the Pitcairn islands (Mathis 1989). On Mo'orea, the glassy-winged sharpshooter of the order Homoptera is most famous, with several eradication methods dedicated to its disposal. Flies of the family Tephritidae, especially the Oriental Fruit Fly (invasive to most of French Polynesia), have also been widely studied as an example of invasive Diptera. However, there are few studies that address the mirroring question: How do invasive plants (or plant microhabitat composition in general) affect insect populations?

The purpose of this research was to apply plant composition studies to the order Diptera, a highly variable and generally non-herbivorous order. Diptera occupy several trophic levels, including parasite, predator, and detritivore. Furthermore, this research sought to utilize the island of Mo'orea, with a well documented history of naturalized, invasive, and native plants as an ideal study area. Sites were specifically chosen along the Opunohu valley's Three Pine Trail, a relatively contained, mid-elevation hiking trail. By limiting elevation range differences and habitat variation beyond plant life (i.e. coastal vs. forested), the author hoped to reduce the number of variables. This research tested for changes amongst family representation (are certain families more prevalent in native/alien/naturalized communities?), biomass numbers (are there more Diptera in certain plant communities?), and family richness. The author hypothesizes that there will be significant differences in all of these factors in each type of plant microhabitat.

METHODS

Study sites

Twelve sites were chosen along the Three Pines Trail, a mid-elevation hiking trail in the Opunohu valley of Mo'orea, an island of French Polynesia.

Sites were chosen based on the prevalence of three types of plant life at each site: native, naturalized, or invasive. Native sites were

categorized by the presence of *Hibiscus tiliaceus* and *Angiopteris evecta*. Invasive sites were categorized by the presence of *Miconia calvescens*, *Spathodea campanulata*, and *Carica papaya*. Naturalized sites were categorized by the presence of *Ionocarpus fagifer* and *Syzygium malaccense*. For this study, naturalized plants are defined as plants that were brought over by the ancient Polynesians in early colonizations of Mo'orea. Sites were ten by ten meters and measured with a transect tape. Finally, because it is virtually impossible to find a ten by ten meter site that is entirely native, invasive, or naturalized plants, sites were categorized as such if a clear majority of plants (at least seventy percent) were of one type. Appendix B lists specific plant counts per site.

Collection Methods

At each site, a Malaise trap was placed at the center (or as close as possible if obstructed) and left for five days, except in the cases of Native site 4, Invasive site 3, and Naturalized site 4, which were left for six days. Insects were killed and stored in seventy-five percent ethanol.

Data Analysis

Diptera were separated from each Malaise trap and keyed to family with the assistance of Borror and DeLong's Introduction to the Study of Insects. In some cases, additional assistance was provided from Biocode researchers.

Numerical counts for Diptera families were converted into percentages of Diptera collected per site (Appendix A, C). Using the statistical program JMP, families were graphed for each site and obvious significant differences were tested using a one-way ANOVA (analysis of variance). Tests were also performed to look at family richness and biomass.

RESULTS

Diptera Family Composition

After Diptera were identified to family, they were analyzed using the program JMP. First, a graph showing the changes of all families over different sites was constructed (Appendix C). From that graph, families showing possible significant differences were tested. The most likely to show possible significance were the families Ceratopogonidae (the blood-sucking midges,

commonly known as nonos) and Cecidomyiidae (gall forming Diptera) (Fig. 1, Fig. 2).

Using a one-way ANOVA test, both families were tested for potential changes at different site types. Neither family returned any significant results. With a p-value of 0.069, the family Ceratopogonidae may be potentially significant. Tests for Cecidomyiidae returned a p-value of 0.134. The other families collected were also tested for significant differences with none found.

Biomass

Biomass was tested in the same manner as family composition (JMP graphics and a one-way of ANOVA). No significant differences were recorded (p=0.309)

Family Abundance

Family abundance was tested using JMP graphics and statistics. A significant difference was reported (p=0.029) between invasive and naturalized sites. Invasive sites had a significantly higher amount of family diversity than naturalized sites. No significant differences were found in comparisons to native sites.

DISCUSSION

Diptera Family Composition

No significant differences were found for any of the families at the three different types of sites. This is in contradiction to the Enemy Release Hypothesis, which for the purposes of this study, would predict that there would be differences in Diptera population composition at the invasive plant sites. If the Enemy Release Hypothesis was occurring, it is likely that there would have been less of the Cecidomyiidae, the gall forming Diptera (which significantly damage plant leaves), in invasive communities.

There are two possible reasons the null hypothesis is supported for this study, the first is that Diptera at my study sites have already adapted to invasive plants and can equally use the resources that they provided. In research that has had similar findings to mine (Sieman et al., 2006), it was recorded that insects (even specialist herbivores) were able to adapt to new plants within 350 years. Other studies show insects adapting within as little as eight (Singer et. al 1993). Certainly, this could have been the case with the Diptera that I collected.

The other possible explanation for my results is that Diptera, as insects that are generally not phytophagous, are not as greatly

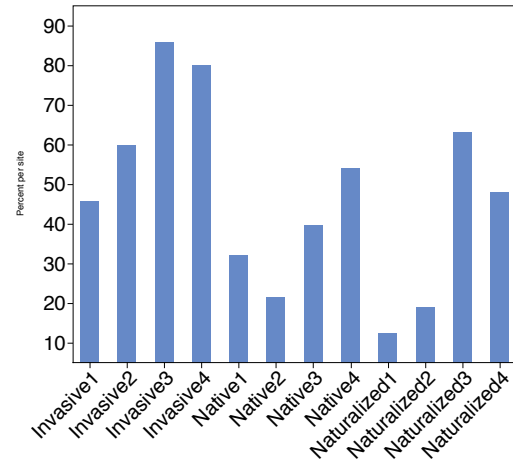


FIG. 1 Percentage of Diptera populations that were Ceratopogonidae at each site.

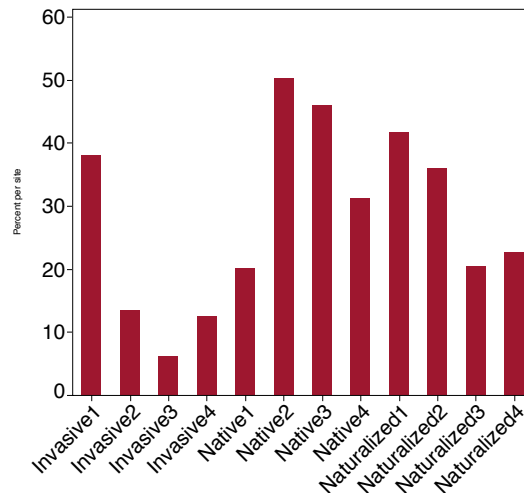


FIG 2. Percentage of Diptera populations that were Cecidomyiidae at each site.

affected by whether plant microhabitats are invasive, native, or naturalized. The observation that non-herbivorous insects are not as greatly affected by plant microhabitats has been documented before in similar conditions. (Proches 2008).

There was one family that was almost significant (p=0.069), the Ceratopogonidae, and it seems that with a greater sample size the ANOVA results might have become significant. This is unusual, however, because the Ceratopogonidae are not herbivorous, but blood feeders. Moreover, they do not prey on other insects, but generally vertebrates. Most likely, they are following a prey source that is attracted to invasive plants. On the Three Pines trail, they are likely feeding on rats or skinks with the occasional feral cat or unlucky

scientist thrown in. Possibly, the presence of invasive plants themselves might create a favorable habitat for larvae by affecting moisture or leaf litter levels.

In addition to natural reasons, this study had one serious experimental error. There were only four replicates per site and in many cases, this small number led to large standard deviations. If there were more replicates, statistical tests may have revealed different results.

Biomass

There were no significant differences found amongst plant community types for biomass. This is also in contradiction of the Enemy Release Hypothesis, which would predict for less biomass at invasive plant sites. This part of the study had its own significant experimental error, although it was not an error that was fully apparent; for one set of traps (Native 4, Naturalized 4, and Invasive 3), the traps were left out for six days as opposed to the regular five due to scheduling conflicts. Only invasive trap 3 showed a remarkable increase (a total of 1,060 Diptera).

Family Abundance

This was the only set of tests that revealed any significant differences between the three types of plant microhabitats. Interestingly, family abundance was not different between native and invasive communities, but invasive and naturalized. I would have expected the difference to occur between the two sites that have the greatest amount of time between their introductions and thus have the greatest chance of divergence in their community structures. Again in this case, I feel that a greater number of replicates would have produced clearer results.

Notes about collecting methods

This research utilized malaise traps as the only collecting method. Malaise traps are extremely effective at trapping insects that fly at moderate heights (3-10 feet), but ill-suited to catching insects that fly at other ranges. It is possible that entire families of Diptera were not collected and records of biomass could have been skewed.

Furthermore, there were limitations to the analysis of data that I collected. My collections were identified to the family level, which was the extent of identification I could do without genera and species keys. However, I have noticed several biomorphs within my families that may possibly represent distinct genera or species. Further analysis of my insects,

utilizing DNA techniques that were not available to me on Mo'orea, may reveal conflicting results. Identifying these Diptera to smaller taxonomic levels is the next step of this research. It is my expectation that this new data will potentially reveal interesting results.

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APPENDIX A

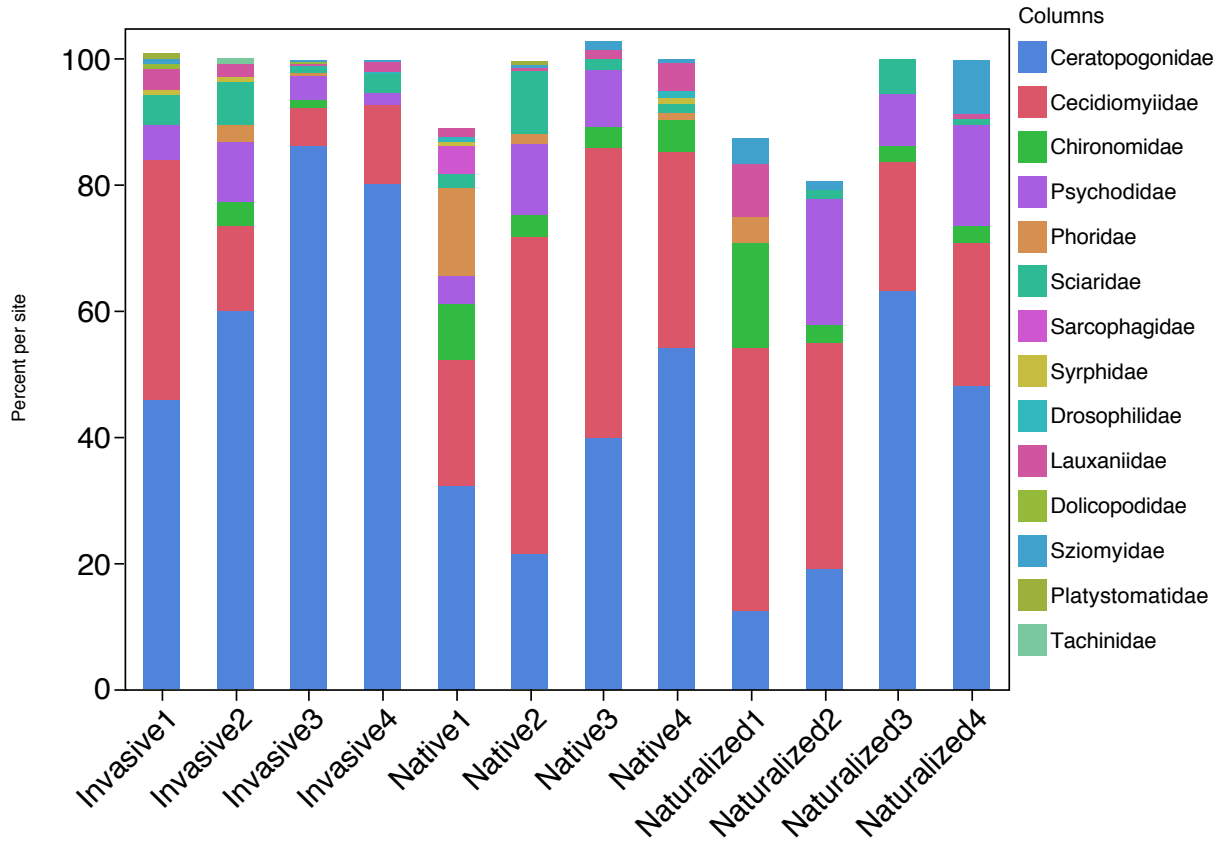
Diptera family percentages per site. Total numbers included.

Sites	Total Number of Diptera Collected	%Ceratopogonidae	%Cecidomyiidae	%Chironomidae	%Psychodidae	%Phoridae	%Sciaridae	%Sarcophagidae	%Drosophilidae	%Syrphidae	%Lauxaniidae	%Dolichopodidae	%Sciomyzidae	%Platystomatidae
Invasive1	124	45.9	37.9	0	5.6	0	4.8	0	0.8	0.8	3.2	0.8	0.8	0.8
Invasive2	105	59.95	13.4	3.8	9.5	2.8	6.7	0	0.9	0.9	1.9	0	0	0
Invasive3	1050	86	6.1	1.2	3.8	0.5	1.03	0	0.00	0.009	0.47	0.18	0.28	0
Invasive4	535	80	12.5	0	2	0	2.9	0	0.37	0	1.6	0	0.18	0
Native1	131	32.2	20	8.8	4.4	14	2.2	4.4	0.74	0.74	1.4	0	0	0
Native2	171	21.5	50.2	3.5	11.1	1.7	9.9	0	0	0	0.5	0	0.5	0.5
Native3	344	39.8	45.9	3.4	9	0	1.7	0	0	0	1.4	0	1.4	0
Native4	196	54	31.1	5.1	0	1	1.4	0	1	1	4.5	0	0.5	0
Naturalized 1	24	12.4	41.6	16.6	0	4.1	0.12	0	0	0	8.3	0	4.1	0
Naturalized 2	142	19	35.9	2.8	20	0	1.4	0	0	0	0	0	1.4	0
Naturalized 3	348	63.1	20.4	2.5	8.3	0	5.4	0	0	0	0	0	0	0
Naturalized 4	106	48	22.6	2.8	16	0	0.9	0	0	0	0.9	0	8.4	0

APPENDIX B

Plant counts per site

Sites	<i>Angiopteris evecta</i>	<i>Hibiscus tiliaceus</i>	<i>Miconia calvascens</i>	<i>Spathodea camapnulata</i>	<i>Ionocarpus fagifer</i>	<i>Syzygium malaccense</i>	<i>Carcia papaya</i>
Native1	9	20	1	0	2	0	0
Native2	0	19	2	0	4	1	0
Native3	9	13	0	0	3	8	0
Native4	0	25	0	0	4	0	0
Naturalized1	3	0	0	0	27	10	0
Naturalized2	3	4	3	0	14	31	0
Naturalized3	5	0	0	0	43	9	0
Naturalized4	2	2	2	0	37	0	0
Invasive1	3	0	22	8	0	5	8
Invasive2	4	2	24	0	0	0	0
Invasive3	2	3	20	0	0	0	0
Invasive4	5	3	23	0	7	0	0



Column 17

APPENDIX C

Graph showing Diptera family composition per site.