Evaluating Diversity: A Baseline Study Comparing the Diversity of the Order Diptera in Two Distinct Sites in the Yucatan Peninsula of Mexico

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A baseline study of the insect order Diptera (flies) was conducted in the Yucatan Peninsula of Mexico (Latitude: 20.0 N Longitude: 90.0 W) in which diversity was compared between two distinct sites: (1) the land immediately surrounding a former sugar cane plantation associated with the Hacienda Tabí (maintained by Fundación Cultural de Yucatán) and (2) the undisturbed dry tropical forest at the Helen Moyers Biological Reserve located at Kiuic (maintained by Millsaps College). It was hypothesized that a richer diversity would be present at the Kiuic site, which is relatively undisturbed, compared to the Tabí site. The following 17 Dipteran families were recorded for both sites: Tabanidae, Stratiomyidae, Asilidae, Culicidae, Mycetophilidae, Tachinidae, Muscidae, Tipulidae, Anthomyiidae, Bombyliidae, Tanypezidae, Syrphidae, Sciaridae, Pipunculidae, Chironomidae, Dolichopodidae, and Conopidae. The Kiuic site also reported 6 additional families: Phoridae, Heleomyzidae, Bibionidae, Scatopsidae, Scenopinidae, and Mydidae. The Tabí site, however, yielded eight additional families: Sarcophagidae, Ropalomeridae, Drosophilidae, Therevidae, Ceratopogonidae, Sciomyzidae, Calliphoridae, and Platystomatidae. Since many of the families individual to the Tabí site are common, these findings were interpreted not to indicate a significant difference in diversity between the two sites. For more conclusive data, more work must be done in the future, both in the identification of these insects to species, and in the studying of specific families.

This paper is a report of a baseline study conducted on the Order Diptera (flies), which was conducted during the early part of the rainy season in the dry tropical forest of the Yucatan Peninsula, an area which is largely biologically unexplored. In addition to establishing a baseline measure of diversity for the Dipterans in this area, an attempt was made to compare the diversity between two distinct sites within the dry tropical forest ecosystem there: (1) the relatively undisturbed forest area of the Helen Moyers Reserve at Kiuic and (2) the land on and surrounding a former sugar cane plantation and current citrus grove at Tabí, which for our purposes was considered to be disturbed, especially when compared to the Kiuic site. Both sites contained approximately 3,500 square acres of land and were separated by a linear distance of 19.7 km.

Dry tropical forests, such as the forest at Kiuic, are the most endangered type of tropical forest and are therefore the most endangered ecosystem type (Janzen, 1988). Essentially, it is the existence of a dry season that makes dry tropical forests so vulnerable. It is during this season that slash-and-burn farming and other destructive and ecologically disturbing human activities can have their greatest effect. Mexico itself is a country very rich in biodiversity, ranking third in overall biodiversity despite its being only the 14th largest nation in the world; over 30,000 plant species, 1,000 bird species, 449 mammalian species, and some hundred thousand different species of insects are found within Mexico (Ramamoorthy et al., 1993). The Order Diptera was chosen as the focus of this research for two reasons: (1) the inherent diversity within the order Diptera, especially in the tropics, and (2) the economic and medical importance of the Order Diptera, particularly in the tropics where they are involved as the vectors or cause of many important diseases of humans, plants, and livestock. Both of the above reasons justifying this research are compounded in importance by many magnitudes by the fact that the particular area of the Yucatan Peninsula that is the focus of this research is largely biologically unexplored and is some of the last remnants of relatively undisturbed dry tropical forest on the planet. On all levels, ecological, economical, and medical, research such as

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this is necessary for the future of studies in this area, and for understanding the overall effect this area and its diversity have on life on this planet as we know it.

METHODS AND MATERIALS

Standard entomological trapping techniques and taxonomic keys were used to capture and identify all fly specimens. Trapping techniques included: sweep nets, malaise traps, yellow pan traps, and black lighting, each of which was individually beneficial.

***Experimental Design of the Study*—**Since the primary focus of this research was the establishment of a baseline level of diversity for the order Diptera in the Yucatan Peninsula, and the secondary focus was the comparison of two distinct sites, the experimental design of this research contains elements of both consistency and spontaneity depending on the nature of the capturing technique. Although it would have been desirable to maintain complete consistency between the two sites, this was found to be an unrealistic possibility due to both the time constraint of the study as well as a lack of specific knowledge about the two areas. Collecting began on the 12th of June and was continued for 9 days. It must also be noted that this collection time coincided with the beginning of the rainy season. The average amount of rain (cm/day) collected at the two sites over the period of the study is documented in Table 1. The average temperature range for the area per day was 22.36–32.08°C.

Table 1. Average rainfall as study sites.

	Average Rainfall (cm/day)
Kiuic	2.12 (range 0.254–5.46)
Tabí	2.77 (range 0.254–6.98)

***Sweep Nets*—**Sweep netting was implemented freely and without any particular experimental design. An estimated 1% of each site was covered by the combined efforts of our research team. Two specific sweep nets were used in this study: (1) a round cloth net with a 15" diameter and 2.5' handle and (2) a diamond-shaped net, made of mesh, with a 4.5' handle, and detachable bottom. This second net was the primary net used because of efficiency in capturing and transferring of flies.

***Malaise Traps*—**Since it was predicted that Malaise traps would be the most beneficial in capturing flies, much attention was given to choosing sites for these traps. Sites were chosen in both the Kiuic and Tabí areas and an attempt was made to vary both the vegetation and amount of light from site to site (Tables 2 and 3). Since the primary goal of this research was establishment of a baseline measure of diversity, and because it was hypothesized that Kiuic would be richer in insect diversity than Tabi, the odd Malaise trap was set up at Kiuic.

***Yellow Pan Traps*—**Two to four yellow pan traps were placed in the immediate area surrounding each Malaise trap.

***Black Light*—**Due to the amount of time required to set up this apparatus, it was only used once at each the Tabí and Kiuic sites. Both the Tabí and Kiuic sites were characterized by a medium amount of both understory and groundcover and minimal canopy. The Kiuic site, in addition, was close to a sinkhole filled with water and it was hoped that this would attract a different variety of insects. No serious attempt was made to capture dipterans using the black light at the Kiuic site, however, because of the poor result obtained at the Tabí site where the black light was used first.

***Identification*—**The two taxonomic keys used in this research were the primary key found in Borror et al. (1992) and the keys specific to the Diptera found in McAlpine (1983). Because only Volume 2 of McAlpine was available at the time of the research and because of time constraints, these keys were not implemented as fully as possible. However all specimens were successfully keyed to family and some were keyed to genus.

RESULTS

A total of 31 different families (Table 3) were reported from the two sites. Seventeen of these were common to both the Kiuic and the Tabí areas: Tabanidae, Stratiomyidae, Asilidae, Culicidae, Mycetophilidae, Tachinidae, Muscidae, Tipulidae, Anthomyiidae, Bombyliidae, Tanypezidae, Syrphidae, Sciaridae, Pipunculidae, Chironomidae, Dolichopodidae, and Conopidae. Six additional families were found at the Kiuic site: Phoridae, Heleomyzidae, Bibionidae, Scatopsidae, Scenopinidae, and Mydidae. Eight families were found at Tabí, but not at Kiuic: Sarcophagidae, Ropalomeridae, Drosophilidae, Therevidae, Ceratopogonidae, Sciomyzidae, Calliphoridae, and Platystomatidae. A total of 245 dipterans were catalogued, 158 from Kiuic and 87 from Tabí. In addition, the high abundance, as determined from the Malaise traps, of the families, Tabanidae, Asilidae, Stratiomyiidae, Syrphidae, and Tachinidae deserves mention here.

Table 2. Description of malaise trap habitats.

Malaise Trap	Location	Habitat Description
Malaise trap K1	Kiuic	Heavy canopy, heavy ground cover, within beam of sunlight
Malaise trap K2	Kiuic	Minimal canopy, heavy understory, minimal groundcover
Malaise trap K3	Kiuic	Open area near path with little overall vegetation
Malaise trap T1	Tabí	Heavy ground cover and understory, minimal canopy, within beam of sunlight
Malaise trap T2	Tabí	Heavy ground cover and understory, medium canopy

Table 3. Dipteran families catalogued from study sites.

Present at Kiuic	Bibionidae, Heleomyzidae, Mydidae, Phoridae, Scatopsidae, Scenopinidae
Present at Tabí	Calliphoridae, Ceratopogonidae, Drosophilidae, Platystomatidae, Ropalomeridae, Sarcophagidae, Sciomyzidae, Threvidae
Present at both sites	Anthomyiidae, Asilidae, Bombyliidae, Chironomidae, Conopidae, Culicidae, Dolichopodidae, Musciade, Mycetophilidae, Pipunculidae, Sciaridae, Stratiomyidae, Syrphidae, Tabanidae, Tachinidae, Tanypezidae, Tipulidae

DISCUSSION

Capturing specimens of 31 different Dipteran families is certainly indicative of the high overall level of biological diversity present in this area, especially considering that this research took place over nine days during the beginning of the rainy season and was limited to only a small fraction (nearing 1%) of the land available to research. Essentially, this work has only just begun. Therefore, the main value of this research lies in its applicability to future studies. Future ecological research in the study areas of Kiuic and Tabí as well as the Yucatan Peninsula at large will not only be able to rely upon the baseline level of diversity established by this research, but will also be able to focus specifically upon the order Diptera.

In my attempt to compare diversity between the disturbed site of Tabí and the undisturbed site of Kiuic it was expected that diversity of the undisturbed forest site would be greater. This expectation, though not supported by these results, fulfilled by this research, is backed thoroughly by other research comparing disturbed and pristine areas (Krijger and Sevenster, 2001; Okwakol, 2000; Andersen et al., 2001). In this study there were two additional families unique to the disturbed Tabí site (8 total) when compared to those of the Kiuic site (6 total), but this can be interpreted as inconclusive for two reasons. First, all of the eight families that were unique to the Tabí site, with one exception, represent families easily obtained in this area, and secondly, there were other factors at the Tabí site contributing these results.

The families of Phoridae, Heleomyzidae, Bibionidae, Scatopsidae, Scenopinidae, and Mydidae which were found at the Kiuic site, are fairly general, as are the families of Sarcophagidae, Drosophilidae, Therevidae, Ceratopogonidae, Sciomyzidae, and Calliphoridae which were found within the Tabí site. The family of Ropalomeridae, represented by one specimen at the Tabí site, does, however, represent the rarest fly within the catalogue that resulted from this research. To designate the Tabí site as more diverse because of one specimen however, would certainly be premature.

The family Drosophilidae may not be the most common of all fly families, but members of this family can be easily found anywhere around rotting and decaying fruit. Therefore, presence of this family at Tabí, which is surrounded by citrus groves, is not surprising. Since no Malaise trap was set up at Kiuic with a fruit-bearing tree within view, it is not very surprising that this family was not represented at Kiuic. Future efforts should be made however, by such methods such as baiting a Malaise trap with fruit, to determine whether this family is present within the Kiuic site.

The absence of the families Calliphoridae and Sarcophagidae at the Kiuic site and their presence at the Tabí site were, most likely, the results of the immediate environments in which the Malaise traps were set and most sweep netting occurred. As mentioned above, the Tabí site is currently surrounded by many citrus groves. In addition, this, the family maintaining that maintains the hacienda on the property has livestock (goats, chickens, pigs) as well as domesticated dogs. The Dipteran families of Calliphoridae and Sarcophagidae would be expected to be more prevalent in an area where humans and livestock live. Calliphoridiae flies, more commonly known as blowflies or greenbottle and bluebottle flies, are particularly attracted to livestock and oviposit on fresh and cooked meat, and dairy products. Many are also attracted to excrement and are therefore of medical importance (McAlpine, 1983). For example, dysentery is often associated with high blow fly populations (Borror et al., 1992). The Sarcophagidae flies, are more commonly known as flesh flies, but this is partly a misnomer because only the larval stages of some of these flies are actually scavengers of decaying animals or parasitic on vertebrates. Most larvae of this family are instead parasitic on other insects, particularly Hymenopterans (Borror et al., 1992). Adult flesh flies feed largely on sap and nectar and do not feed on flesh at all. Members of both of these fly families, but especially those of the Calliphoridae, may be involved in myiasis, the parasitic infection of humans and animals by fly larvae. In conclusion, both of these families are common, but would be expected more in an area with humans and other animals nearby. It is encouraged however, that future research, in addition to focusing on the abundance of flies from the Tabanidae, Asilidae, Stratiomyiidae, Syrphidae, and Tachinidae families, also focus on positively identifying Calliphoridae and Sarcophagidae flies at the Kiuic site. Essentially, the complete absence of Calliphoridae and Sarcophagidae at the Kiuic site would be indicative of definite ecological disturbance, and purposeful efforts, such as traps baited with carrion, dung, or other material, should be used in retrieving these two families from this site.

In conclusion, the true value of this research lies in its applicability to future research efforts. Possibilities of such research are seemingly endless. First, since this research established a baseline for dipteran diversity, future efforts may be focused on monitoring diversity on a yearly basis, as well as collecting data for the entirety of both the dry and rainy seasons. Second, many specific research opportunities are particularly pressing, such as assessing abundance or absence of certain families within these study areas. This research can also be the foundation of many general ecological studies in the future. Finally, since many families were present, or at least, known to be present, which are involved in disease transmission, it is personally desired that future research be directed toward medical entomology and tropical medicine. Though results of this study were inconclusive in showing that the undisturbed tropical forest area at Kiuic had a higher diversity than the disturbed land surrounding the Hacienda Tabí, it fulfilled its purpose in establishing a baseline level of diversity for the insect order Diptera. Such research may lead to the improved classification of the organisms of this area, preservation of these areas through habitat management, and increasing our understanding of the concepts behind biodiversity.

I suggest that such future studies begin by focusing on the abundance of the Dipteran families of Tabanidae, Asilidae, Stratiomyiidae, Syrphidae, and Tachinidae and the ecological problems that these abundances might indicate. Such abundances could indicate declining levels of overall plant and insect diversity (Haddad et al., 2001). It must be stressed however that this is only a possibility since there is no prior research containing diversity levels with which to compare these results. Furthermore, since this and the research of my colleagues who studied the Coleoptera and Hymenoptera, are the first established baselines of diversity for this area, the ecological monitoring of this area must begin now.

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