Proceedings of the 1st Joint Symposium on the Natural History and Geology of The Bahamas

June 12-16, 2015

Conference Organizer:
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Gerace Research Centre
San Salvador, Bahamas
2017

ISBN: 978-0-935909-40-1

Cover image - Patch reef near the wall off Grotto Beach (photo by Lee Florea).

Preliminary analysis of hurricanes as extrinsic factors influencing Bahamian insect biodiversity

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1. Abstract

MacArthur and Wilson's ideas about island biogeography have been applied to many different systems in an attempt to better understand biodiversity. However in many cases, the basic concepts they describe do not completely explain the variation observed in natural systems. Island size, distance from colonization source and extinction rates have been found to account for as much as R = 0.5 of the distribution of major Bahamian insect groups (i.e. 25% of the variation). If, however, we overlay other extrinsic factors, such as hurricanes, it might be possible to increase the predictability of the available models and more completely describe insect biodiversity in the Bahamas.

The islands, oriented from northwest to the southeast, consistently catch storms moving off the coast of Africa in the autumn and this predictability adds yet another wrinkle to the biogeographical distribution of the insect communities. The size of the island potentially creates a refuge from the high winds and heavy rainfall that are hallmarks of hurricanes.

Since October 2004, surveys of the insect communities on San Salvador, the Bahamas, have been made using net collection of individuals, sweep sampling of the vegetation, malaise traps and yellow-bowl traps for ground dwelling insects. Insect families have been observed to vary seasonally with predictable increases following hurricane disturbance, but there were no consistently seen dominant groups (orders or families) following hurricanes with a major San Salvador impact during 2004-2013. The dominant groups observed perhaps reflect the first groups to become re-established rather than anything else. These data provide a basis for future comparisons of insect community recovery following major hurricane impact on San Salvador and other Bahamian islands.

2. Introduction

MacArthur and Wilson's (1967) hypotheses about island biogeography have been applied to many different systems in an attempt to gain an understanding of biodiversity. However, in many cases, the basic concepts they describe do not completely explain the variation observed in natural systems. Such is the case for the insect distributions observed in the Bahamas. If, however, we include the influence of other extrinsic factors, such as hurricanes, it might be possible to increase the predictability of the available models and more completely describe island biogeography in the Bahamas.

Island size, distance from colonization source, and extinction rates are the basic components of MacArthur and Wilson's arguments, and these have been found to account for as much as R = 0.5 of the distribution of major Bahamian insect groups (i.e. 25% of the variation; D. Smith, unpublished data). These broad categories, especially island size, might influence factors such as rainfall and temperature within island habitats, as well as the severity of predictable weather patterns in specific island locations. The Bahama Islands, oriented from southeast to the northwest, consistently catch storms moving off the coast of Africa in the autumn, and their predictability adds yet another wrinkle to the biogeographical distribution of the insect communities. The size of the island potentially creates a refuge from the high winds and heavy rainfall that are

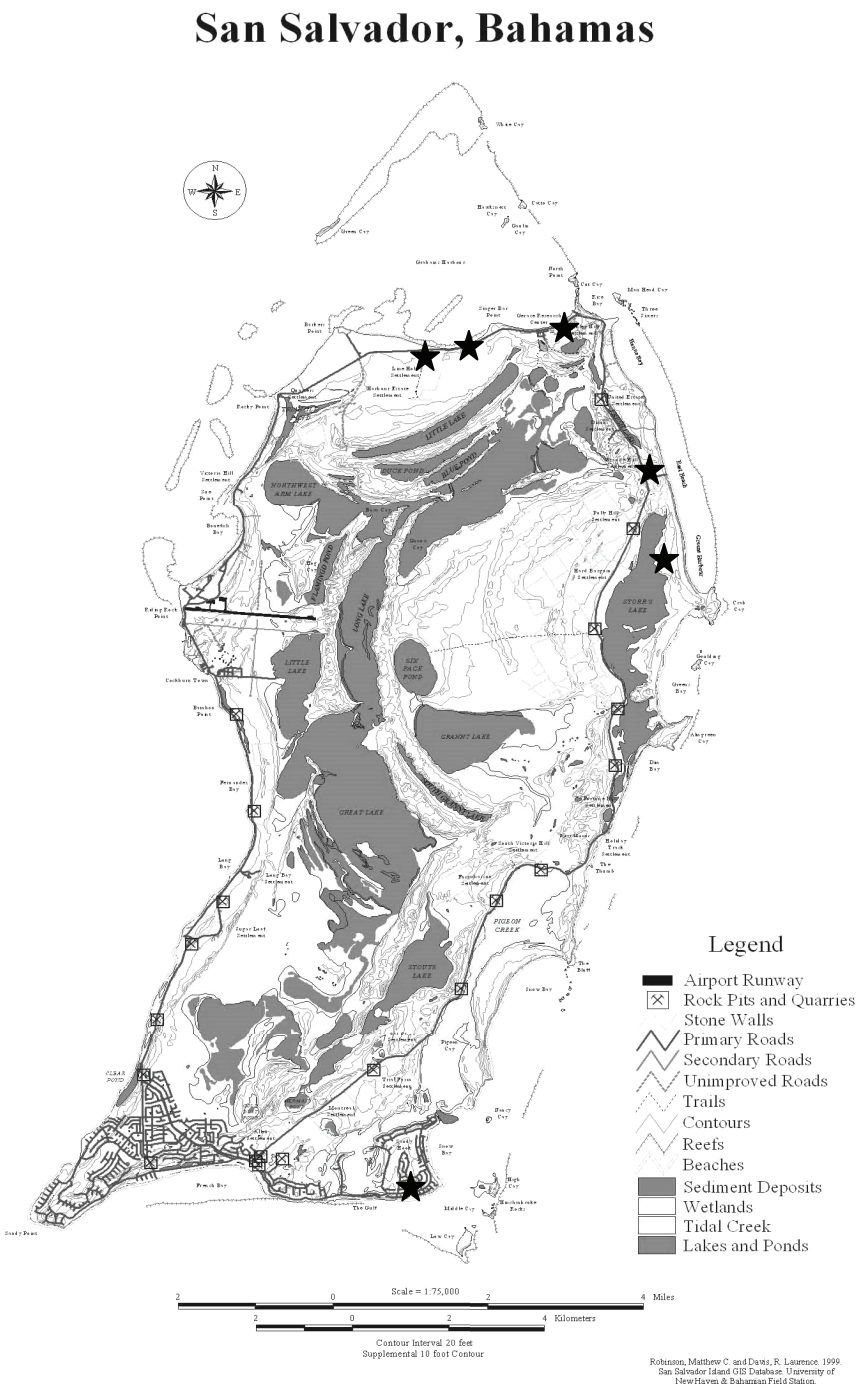

Figure 1. San Salvador Island, The Bahamas, with locations of sampling sites (stars) following hurricanes Frances, Irene, and Sandy.

hallmarks of hurricanes.

Here we report on the effects of three recent hurricanes (Frances, Irene and Sandy) on insect diversity in the Bahamas, particularly in relation to the diversity of insect orders on San Salvador Island in The Bahamas. We anticipate further investigations on other taxonomic levels in future studies.

3. Methods

Since October 2004, surveys of the insect communities on San Salvador Island, The Bahamas, have been made using net collection

of individuals and sweep sampling of the vegetation following Hurricanes Frances (Category 5, September 2004), Irene (Category 2, August 2011), and Sandy (Category 3, September 2012), and again in the year following each event. Insects were collected at six locations on San Salvador: Jake Jones Road, Hard Bargain (trailhead), Parrot Road, Harbour Yard (inland trail), East Beach (Brandy Hill Road) and Graham's Harbour (Figure 1).

Large nets were used to hand-capture insects. Typical insects caught using this technique are bees, butterflies, dragonflies and damselflies, and grasshoppers. Sweep samples were also taken, fifty sweeps along each of three to five transects per site, using heavy-framed canvas sweep nets. Comparable collecting efforts (in person hours) were made at each site. Samples were frozen and later sorted and identified to the ordinal or familial rank at the Gerace Research Centre (GRC). Voucher specimens have been deposited in the Bahamian National Insect Collection, Nassau, New Providence and/or in the Repository at the GRC.

4. Results

The most common insect orders in The Bahamas are represented in the samples we collected, but not all groups were represented immediately following the hurricanes, and the relative abundance of specimens representing these groups differed between hurricanes (Figures 2-4). Insect families varied seasonally, with predictable increases following hurricane disturbance (post-hurricane sampling occurring within two-three months of hurricane impact). The order Diptera generally had the highest or near the highest number of families collected (Figures 2-4), followed by Lepidoptera and Hymenoptera after Hurricane Frances. The longer term follow-up after Frances (three years) showed general increases in the number of orders present and for some orders, the number of families (Figure 2B). Diptera and Coleoptera had the highest number of families following Hurricanes Irene and Sandy; fewer orders overall were collected following both those hurricanes, even one year after Hurricane Sandy (Figures 3-4). The maximum number of sixteen families occurred in the order Diptera, three years after Hurricane Frances and one year after Hurricane Sandy (Figures 2B and 4B).

5. Discussion

There was no consistency in numerically dominant families within any of the orders represented after the three hurricanes that had a major impact on San Salvador during 2004 - 2013. The most abundant groups observed following those hurricanes perhaps reflect the first groups to become re-established rather than anything else. These data provide a basis for future comparisons of insect community recovery following major hurricane impact on San Salvador.

Similar studies on other Bahamian islands, particularly those more frequently impacted by hurricanes, are needed. Of the major Bahamian islands, Abaco (3.9 years), followed by Grand Bahama (4.06 years) and Eleuthera (4.18 years) have the highest frequency of direct hits by hurricane-force winds that persist for more than a few hours (Anonymous 2010). Collections on these, and other, islands will give us a more complete picture of the impact of these major disturbances on Bahamian insect biodiversity.

6. Acknowledgements

Thanks to Shannon C. Smith, the Gerace Research Centre, Le Moyne College, Siena College, The Ohio State University, and legions of students from all three colleges who have helped with collection, sorting, and identification of specimens. Funding for travel was provided by the Le Moyne College O'Leary International Travel Fund and Research and Development Committee (D. Smith, S. Smith), and by The Ohio State University (Landry). Permission for this work was granted by the BEST Commission and Ministry of Agriculture in The Bahamas.

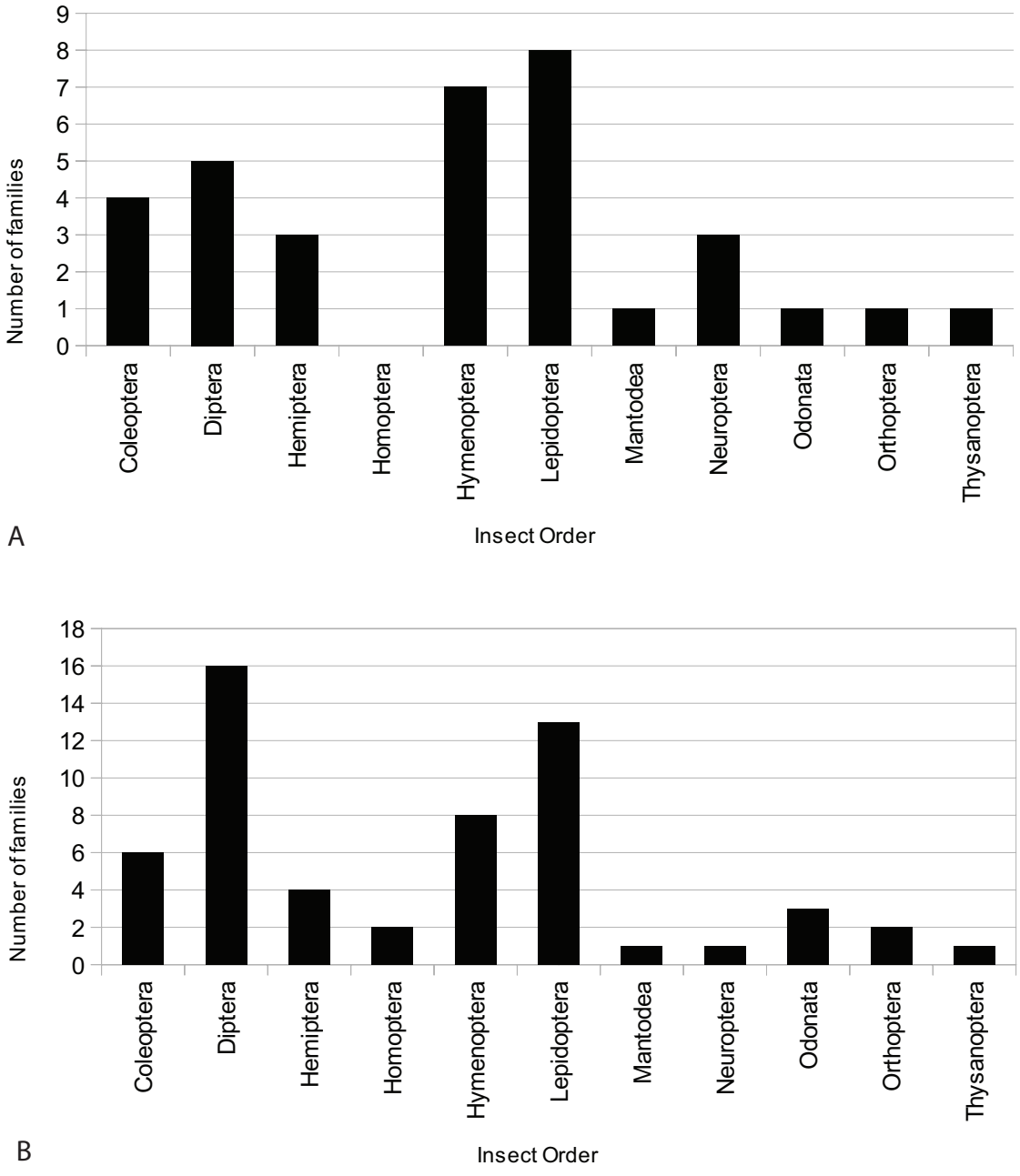

Figure 2. Total number of insect families represented by collections made A) in October 2004 following Hurricane Frances, and B) in 2007, three years after Hurricane Frances.

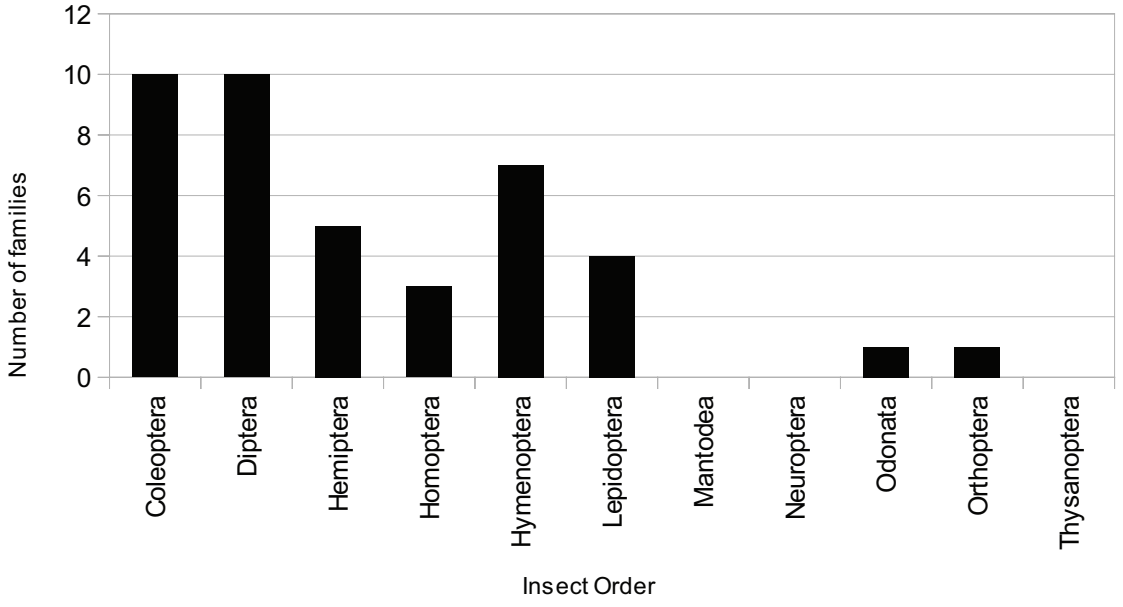

Figure 3. Total number of insect families represented by collections made in December 2011 following Hurricane Irene.

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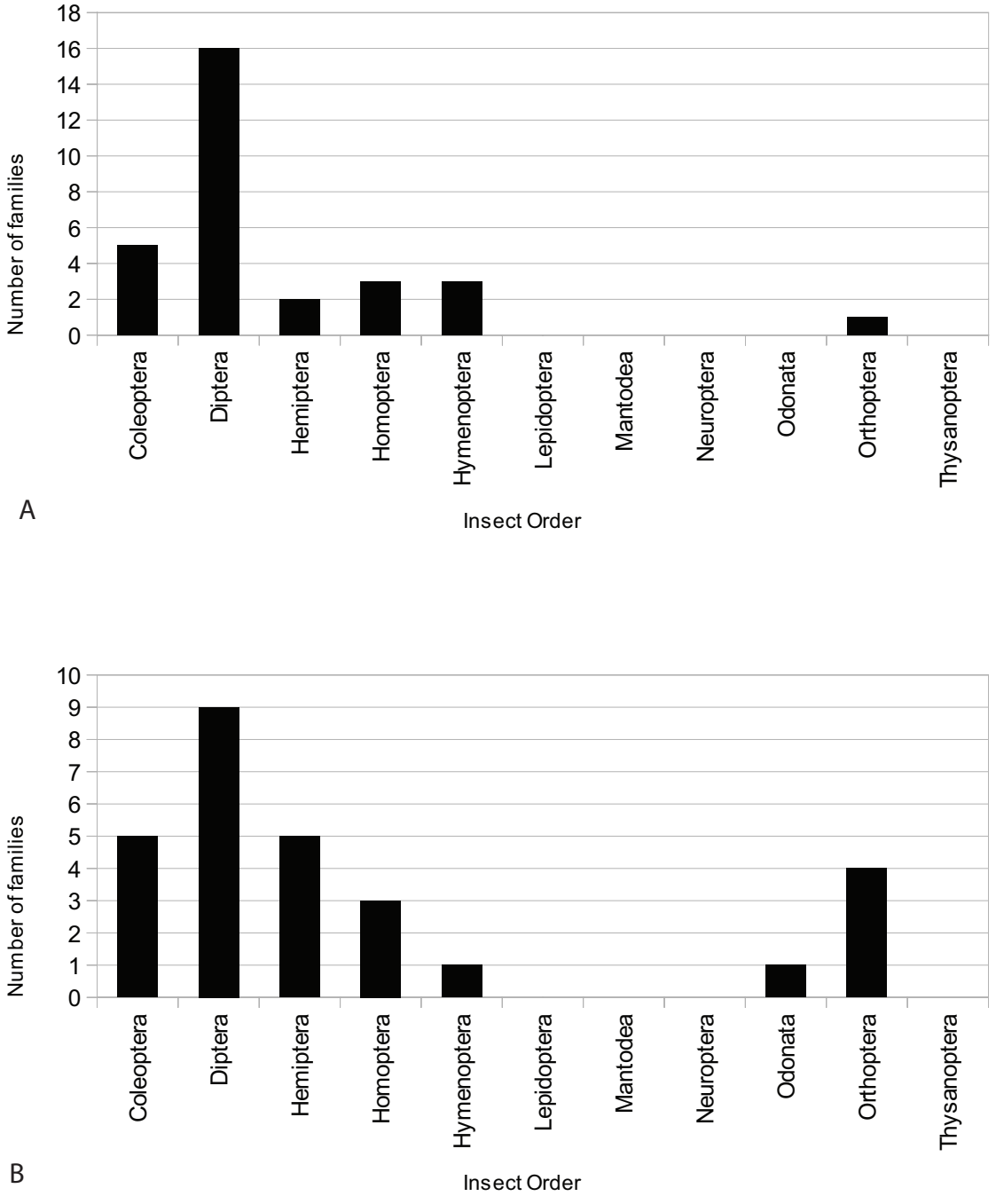

Figure 4. Total number of insect families represented by collections made A) in December 2012 following Hurricane Sandy, and B) in 2013, one year after Hurricane Sandy.