
A Comparison of the Effects of Mangrove Ecosystems (Disturbed and Undisturbed) on the Populations of Birds and Fishes at Hope Beach, East Coast Demerara, region 4, Guyana

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Mangroves are very productive ecosystems that provide habitats and food to many terrestrial and aquatic organisms. However, humans constantly degrade mangroves for agricultural purposes, near shore mining, fishing, the construction of infrastructure and other activities, which destroy the habitats of many organisms. This study compared the population of birds and fishes in two mangrove sites that were categorized as disturbed and undisturbed. From the results obtained it was observed that the populations of birds and fishes were higher in the undisturbed compared to the disturbed. However, the disturbed site had a higher forest density. Moreover, the undisturbed site comprised of a mixed mangrove forest with three mangrove species, while the disturbed had one species. Further, this study emphasized how anthropogenic activities affect birds and fishes utilizing mangrove forests for survival. It was revealed that little to no disturbance in a mangrove forest encourages higher populations of living organisms particularly birds and fishes.

Keywords: Mangroves, Anthropogenic activities, ecosystems, degraded, undisturbed, disturbed

Introduction

Mangrove ecosystems are a mosaic of different types of forest, with each type providing different physical habitats, topology, niches, microclimates, and food sources for a diverse assemblage of animals (Robert *et al.*, 2006). Hundreds of birds and fishes are sometimes found in mangroves thus, the mangrove ecosystems exhibit a steep environmental gradient between inland and marine systems, providing a unique, selective environment that shapes local morphological, physiological, and behavioral adaptations (Tomlinson, 1986). Fish and invertebrates from the marine environment are

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frequent visitors to mangrove communities, as are birds and mammals from nearby terrestrial systems. Studies have shown that mangroves are known to support from four to over thirty times the number of fish compared to adjacent seagrass beds (Beckman, 2013). Furthermore, mangroves play an important role for migratory water fowls, mainly as roosting sites during high tide, but also as places of shelter and foraging.

However, in recent years, anthropogenic pressures have significantly damaged the world's mangroves, with alarming levels of habitat loss affecting all wildlife utilizing the mangroves. It has been estimated that at least 35% of the area of mangrove forests has been lost in the past two decades exceeding that of tropical rainforests and coral reefs (Valiela *et al.*, 2001). In Guyana, the coastland in Regions 2, 3, 4, 5, 6 and the city comprise 89.1 percent of the population that resides in the close proximity of mangrove ecosystems and it was found that the mangrove protective belt has deteriorated due to the harvesting of mangroves (Ferrier, 1992). These forests are the major coastal ecosystem found in Guyana, and are among the richest and most productive bionetworks. Seven species of mangrove have been identified to date with three of these species being dominant along the shorelines of Guyana. These are: *Avicennia germinans* (Black mangrove), *Rhizophora mangle* (Red mangrove) and *Laguncularia racemosa* (white mangrove) (GFC, 2005).

The study area was Hope village, located along the coastal shoreline of the East Coast of Demerara, Guyana. This area comprised of a dense mangrove forest, which spanned the mudflats of the coast across the village and adjoins that of the neighbouring villages. The disturbed area was severely affected by anthropogenic activities including a construction project and mass clearing of the mangroves to accommodate machinery and construction equipment as well as channelization of the Hope Canal. It was dominated by the black mangroves and the clearing of these mangroves resulted in blockage of the original water source. As a consequence hundreds of small fishes and macro invertebrates were affected since there was no water for survival. Additionally, the remaining mangroves had begun to desiccate. The undisturbed area, comprised of the mixed forest and was supplied readily with salt/brackish water from the tide. The species of mangrove plants found in the undisturbed site were the black, white and red mangroves. This site was populated with younger mangroves and was observed to be a greener forest when compared to the disturbed. Fishing activities were observed in the undisturbed site since some fishermen utilize the area, but there was little to no evidence of disturbance occurring and the mangroves there were not affected.

Objectives: This study focused on comparison of birds and fish diversity at disturbed and undisturbed mangrove ecosystems at Hope beach site, East Coast Demerara, Guyana.

Materials and methods

The sites were studied and compared to ascertain the population of birds and fishes and their richness. Sampling took place one day per week within the hours of 8:00 to 18:00hrs for four days per month, yielding a total of twelve surveys for the entire duration of the project, which was conducted for three months. The sites were considered large transects and all species identified within were recorded.

Survey of Birds

The point count method was employed by walking every five meters and recording all birds using their sounds/calls for identification within the transects for both sites. Birds were also identified using binoculars. The numbers and species were recorded and separated according to the site identified.

Collection of fishes

Fishes were collected using dipnets, castnets and hooks with bait. The time of collection varied with the tide in site one (Undisturbed) while collection in site two (disturbed) was done in the mornings at approximately 09:00am and afternoon at 16:00hrs.

Estimating DBH and mangrove population density

The following procedure was adopted for determining the DBH of the mangrove trees in the plots (Pearson *et al.*, 2005). A 100x 100m transect was established and further divided into three diagonal plots where the measurements were done.

Results and Discussion

The results from the surveys conducted on fishes indicated that the Undisturbed site had a higher species richness when compared to the disturbed site . A total of nine species of Fishes were identified and collected (Table 1).

Table 1 Total number of species and individuals of fishes collected during the course of the twelve weeks surveys from both disturbed and undisturbed sites

Species	Undisturbed	Disturbed
<i>Colomesus psittacus</i>	7	0
<i>Sciades couma</i>	10	0
<i>Sciades passany</i>	1	0
<i>Anableps microlepis</i>	3	0
<i>Anableps anableps</i>	10	0
<i>Trinectes maculatus</i>	1	0
<i>Cichlasoma bimaculatum</i> .	0	3
<i>Plagioscion squamissimus</i>	1	0
<i>Mugil cephalus</i>	8	0
Total	41	3

Fishes

Sciades couma and *Anableps anableps* dominated the undisturbed site, while the disturbed site the habitat for one species, *Cichlasoma bimaculatum*, which had a very low population number. The *Sciades couma* is a marine catfish of South American origin and is native to Brazil; French Guiana; Guyana; Suriname; Trinidad and Tobago and Venezuela. It has been assessed by the IUCN as a species of least concern and is restricted to turbid waters in estuaries and the lower reaches of rivers. It is also a valuable food source because of its tender, nutritive meat (IUCN, 2010). *A. anableps* are demersal fishes found mainly in freshwater and occasionally in brackish parts of lagoons and mangrove coastlines. They are native to Venezuela, Guyana, Trinidad and Tobago and the Amazon delta in Brazil. This species has not yet been assessed by the IUCN. Their diet consists mainly of insects, diatoms living on the shore mud, small fishes and other invertebrates (Avery and Bowmaker, 1982). Simpson's diversity index was used to determine the diversity of the two sites and it was discovered that the undisturbed was more diverse and richer than the disturbed; was a larger open environment that provided abundant food sources and optimal conditions for survival. Stomach content analyses were done primarily to ascertain the diet of the fishes in relation to mangroves because it was necessary to determine if they relied on the mangroves directly for their meals. The fishes collected from the undisturbed site consumed a variety of food matter ranging from zooplanktons to small insects such as water beetles, crustaceans such as small crabs and shellfish, which included small shrimps whereas the species collected from the disturbed site was a consumed mainly detrital matter. The ecological variances between the sites accounted for such differences. Furthermore, Beckman (2013) conducted studies showed that

zooplanktons including crab larvae are the most valuable food source for larval and juvenile fishes using the mangroves, while small crabs and shrimps can be the most important food link from the detritus to the larger fishes within the mangroves. Thus, the undisturbed site had an abundant supply of water from the sea so more fishes were able to utilize the mangroves. However, the disturbed site had a limited water source, which was continuously altered due to human interferences. This accounted for the differences in species richness as well as populations of fishes in the two sites.

Birds

A total of forty two species of birds were identified collectively from both sites with members of the Ardeidae family being the most dominant in the Undisturbed site, while members of the family Tyrannidae dominated the disturbed sites (Table 2).

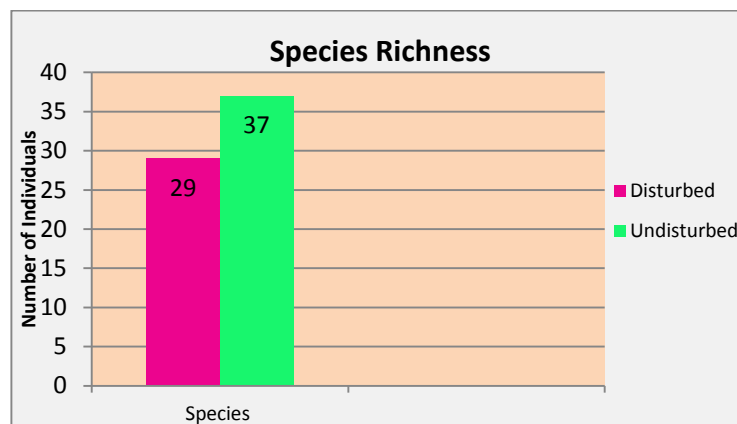
Table 2 Total numbers of birds identified from both sites during the course of the 12 weeks surveys

Species	Scientific name	Undisturbed	Disturbed
1. Scarlet ibis	<i>Eudocimus ruber</i>	128	1
2. Little blue heron	<i>Egretta caerulea</i>	147	4
3. Magnificent frigate	<i>Fregata magnificens</i>	223	9
4. Grey breasted martin	<i>Progne chalybea</i>	62	52
5. Blue grey tanager	<i>Thraupis episcopus</i>	4	28
6. Little egret	<i>Egretta garzetta</i>	124	11
7. Smooth billed ani	<i>Crotophaga ani</i>	4	47
8. Snail kite	<i>Rostrhamus sociabilis</i>	41	29
9. Ruddy ground dove	<i>Columbina talpacoti</i>	5	32
10. Western sandpiper	<i>Calidris mauri</i>	78	0
11. Yellow oriole	<i>Icterus nigrogularis</i>	3	31
12. Solitary sandpiper	<i>Tringa solitaria</i>	5	0
13. spurwing	<i>Jacana jacana</i>	2	16
14. Greater egret	<i>Ardea alba</i>	41	5
15. Cattle egret	<i>Bubulcus ibis</i>	5	7
16. Pied water tyrant	<i>Fluvicola pica</i>	5	22
17. southern house wren	<i>Troglodytes aedon</i>	0	13
18. snowy egret	<i>Egretta thula</i>	22	0
19. Greater kiskadee	<i>Pitangus sulphuratus</i>	20	56
20. American redstart	<i>Setophaga ruticilla</i>	2	1
21. striped wood creeper	<i>Xiphorhynchus obsoletus</i>	2	2
22. shiny cowbird	<i>Molothrus bonariensis</i>	1	0

Table 2 (Con.)

23.	common ground dove	<i>Columbina passerina</i>	7	7
24.	rusty margin flycatcher	<i>Myiozetetes cayanensis</i>	1	13
25.	road side hawk	<i>Rupornis magnirostris</i>	10	0
26.	turkey vulture	<i>Coragyps atratus</i>	16	0
27.	glossy heron	<i>Egretta caerulea</i>	6	0
28.	least sandpiper	<i>Calidris minutilla</i>	25	15
29.	cocoi heron	<i>Ardea cocoi</i>	9	0
30.	striated heron	<i>Butorides striata</i>	3	6
31.	lesser kiskadee	<i>Pitangus lictor</i>	10	59
32.	rock pigeon	<i>Columba livia</i>	1	1
33.	bi-coloured conebill	<i>Conirostrum bicolor</i>	1	0
34.	Rufous crab hawk	<i>Buteogallus aequinoctialis</i>	1	0
35.	yellow crowned caracara	<i>Milvago chimachima</i>	1	0
36.	brown pelican	<i>Pelecanus occidentalis</i>	1	0
37.	tricoloured heron	<i>Egretta tricolor</i>	6	0
38.	southern lapwing	<i>Vanellus chilensis</i>	2	6
39.	glittering throated emerald	<i>Amazilia fimbriata</i>	0	1
40.	crimson crested woodpecker	<i>Campephilus melanoleucos</i>	0	1
41.	pale breasted thrush	<i>Turdus leucomelas</i>	0	3
42.	yellow chinned spinetail	<i>Certhiaxis cinnamomeus</i>	0	2
Total			1024	480

According to Simpson's Index of Diversity the disturbed site was more diverse when compared to the undisturbed site. However, the undisturbed site had higher species richness (Fig 1). Birds from the tyrannid family, which is known to be the largest family of birds with over 365 species identified to date, dominated the disturbed area. Family Tyrannidae are found in habitats ranging from hot, wet tropical forests to dry deserts and inhospitable mountains at heights that insects still can live.

**Fig 1** Species richness of birds for both sites

Additionally, most tyrannids require trees in combination with open areas where they can sight prey from a perch and fly out to catch insects in midair. Some species stay mainly below the lower canopy, in shrub-like vegetation; others perch within the higher canopy where tree vegetation is sparse and affords room to maneuver (Dunning, 2008). This supports that the disturbed site was a tolerable environment for the birds that are adapted to survive under anthropogenic conditions. The disturbed site was considered disturbed because the construction of an eight door sluice was taking place during the study period and activities such as land clearing (of the mangroves) took place, debris was scattered throughout the site as well as construction equipment. Moreover, human refuse such as food droppings, garbage, and all other unwanted edible materials provided ideal conditions for insects such as flies, wasps, and arboreal insects, which usually constitute the main diet of birds from the family Tyrannidae, thus encouraging them to inhabit the site. The lesser kiskadee (*Pitangus lictor*) was discovered to be the most dominant species within this site and foraging was one of the main activities observed. It is classified as least concern on the IUCN red list of threatened species since it is fairly common and is native to countries such as Guyana, Venezuela, Columbia and other South American countries. It appears like a much smaller version of the very familiar Great Kiskadee, *Pitangus sulphuratus* (which was the 2nd dominant species). These species are well adapted to live in human disturbed environments, feeding off insects, and food scraps from humans. The Grey breasted martin (*Progne chalybea*) was the third dominant species with a total of fifty-two individuals identified. Grey-breasted martins are gregarious birds that hunt for insects in flight especially Hymenoptera (mainly winged ants), Odonata, Lepidoptera (butterflies and moths) and Isoptera (termites). Foraging and mating rituals were the main activities observed.

The undisturbed site, on the other hand, was dominated by the Ardeidae family. The Family Ardeidae belongs to the Order Pelecaniformes, and includes herons, egrets, bitterns, night-herons and allies and is usually termed as migratory waterfowls. These wetland birds mostly prey on fish, frogs and other aquatic species, while some prefer foraging on land and they may take lizards, snakes and large insects, such as the Cattle Egret. Parrish and Sherry (1994) reported that migratory birds visiting the mangroves may fly long distances to find food and nesting places there. This was particularly occurring in the Neotropics where seventy-seven bird species have been recorded in the Pacific mangroves of Colombia. The undisturbed site provided optimal conditions for foraging since there were little to no disturbances in the ecosystem when compared to the disturbed site. Additionally, the mangrove forest was denser and more exposed to the ocean's tide. This allowed crustaceans to inhabit the

forest floor abundantly, which was very favourable for the birds. However, since the original water source in the disturbed site was cut off due to the construction activities, there was less water thus, less crustaceans and subsequently fewer birds from this family. In the undisturbed site, the magnificent frigate bird (*Fregata magificens*) was the most dominant species with a total of 223 individuals identified during the course of the 12 weeks survey. Their diet consists of small fishes, squid, jellyfish and crustaceans. They may also feed on young turtles, birds and eggs. The magnificent frigatebird lives on ocean coasts and islands and in breeding season they will resort to live on mangrove islands. They also occurs over tropical and subtropical waters off America, between northern Mexico and Ecuador on the Pacific coast and between Florida and southern Brazil along the Atlantic coast with populations on the Galápagos Islands in the Pacific and the Cape Verde islands in the Atlantic as well (Bird life international, 2012). The second most dominant species was the little blue heron (*Egretta caerulea*). The little blue heron feeds mainly on a diet of fish and crustaceans, but this versatile predator may also consume a variety of frogs, tadpoles, insects, snakes, lizards and small mammals, often moving onto land to feed in grassy meadows. The little blue heron nests in coastal areas, where it builds its nest in shrubs and small trees in standing water or on elevated sites on islands. It typically forages in freshwater lakes, marshes, swamps, streams, rivers and ponds, or in artificial wetlands such as canals, ditches or flooded agricultural fields. Outside of the breeding season, the little blue heron is also frequently found in mangroves. The Scarlet Ibis (*Eudocimus ruber*) was the third most dominant species. It belongs to the family Threskiornithidae. Their diet consists of shrimp and other similar fare like small crabs, mollusks and other crustaceans as well as insects such as ground beetles. They are usually found in wetlands and other marshy habitats, including mud flats, shoreline, shallow bays and rainforests. The range of the scarlet ibis is very large, and colonies are found throughout vast areas of South America and the Caribbean islands. All species from this site were engaged mostly in foraging activities on the mudflats of the shore between the saplings of mangroves where the crustaceans abundant.

DBH of mangroves and soil tests to determine forest density/regeneration process

From this study it was found that the undisturbed site consisted of a mixed mangrove forest. There were three species found in this environment and these were the black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*) and the white mangrove (*Laguncularia racemosa*). The

disturbed site on the contrary, was dominated with one species of mangrove and that was the black mangrove (*Avicennia germinans*). There was little evidence to show that the forest was a mixed one and this implied that the red and white mangroves are not as so adaptive to changing environments especially those of high anthropogenic activities. Thus, it was established that the undisturbed site was more diverse in mangrove species when compared to the disturbed. Moreover, it was noted that the disturbed was an older forest when compared to the undisturbed site that comprised a relatively young forest. This was evident in the differences in measurements of the trees at diameter breast height as well as their total heights, bark colour of the trees and density of the foliage. Furthermore, it was observed that the undisturbed site consisted of a more diverse marsh, which was dominated with seedlings and saplings of all three species of mangroves (red, black and white), while the disturbed site had sparse populations of seedlings and saplings of only the black mangrove. Prior studies conducted by Walters *et al.*, (2006) showed that the creation of gaps by loss of branches or trees allows light to reach the seedlings and propagules in the understory, which quickly grow to fill the gaps, thus lowering soil redox potential. Also higher soil temperature with increased sulfide levels and changes in salinity can all affect regeneration in gaps of the mangrove forests. Thus, it was established that the process of regeneration was more effective in undisturbed site in comparison to disturbed site that was more populated (with older trees). However, there were no significant differences in the densities of the mangrove forests between the two sites (Fig. 2). The density of the undisturbed site was recorded as forty six individuals growing in one square meter, while the disturbed was found to have eighty five individuals per square meter. This higher density in the disturbed site suggested that the mangrove forest was once ecologically rich. However, as anthropogenic activities began taking place the health of the forest deteriorated. These findings correlated with a study conducted by Wah *et al.*, (2011), which showed that disturbed and undisturbed mangrove sites in Semporna, Malaysia does not vary with the disturbed sites having a higher population density than the undisturbed. The disturbed mangrove area had more scattered and randomly distributed tree stands as a result of the activities of local communities in that area such as collection of wood for personal use and it was a similar scenario with the disturbed site from this study.

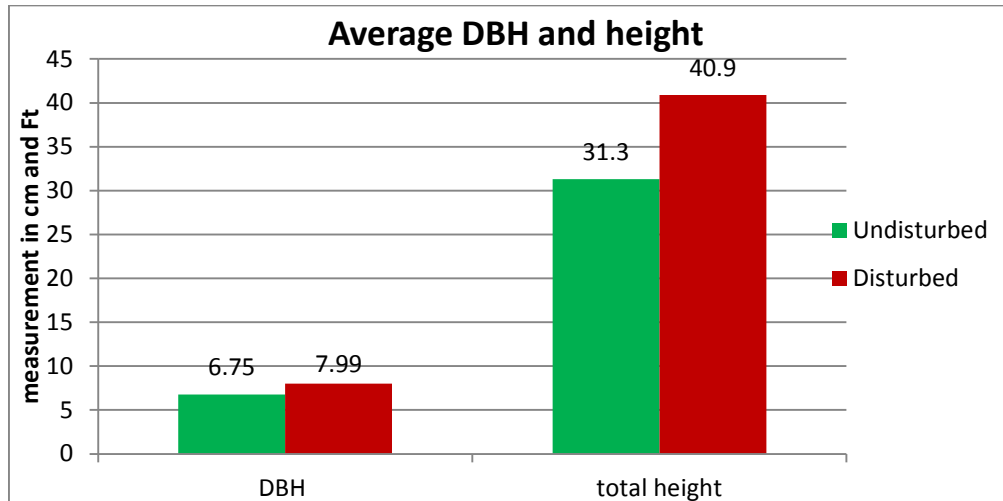


Fig. 2 Average DBH and total height of mangrove trees for both sites

A t-test was performed to determine the overall significance of the project and the results are depicted in Table 3.

Table 3 t-Test analyses conducted on the data obtained from both study sites

Parameters tested	P(T<=t) one-tail	T-Critical one-tail	P(T<=t) two-tail	t -Critical two-tail	Significance
Birds	0.05062	1.663649	0.10124	1.989319	Not significant
Fishes	0.003158	1.76131	0.006315	2.144787	Significant
DBH	0.087435	2.131847	0.17487	2.776445	Not significant

There were no significant differences between the bird populations within both sites. Although the undisturbed site had higher populations of birds, the disturbed site had a higher diversity. Furthermore, there were significant differences between the populations of fishes from both sites as explained earlier. There were no significant differences found between the DBH of mangrove trees within the sites and this was mainly because the disturbed site had older trees compared to the undisturbed site, which had younger trees that were growing rapidly. However, it was observed that the understory layer of the undisturbed site was much richer than that of the disturbed site and there would have been a significant difference had this study focused on that aspect of the ecosystem. Additionally, the understory layer of the undisturbed site is an indicator of the ability of the mangrove forest there to regenerate itself thereby promoting a balanced ecosystem. However, the understory layer of the disturbed site indicated that the mangrove forest might eventually be lost if

action is not taken to reforest/protect it and it will be difficult for a balanced ecosystem to establish itself.

Conclusion

It can be concluded that the disturbed site had a higher diversity of birds compared to the undisturbed site and majority of the birds belonged to the Tyrannidae family. The undisturbed site, however, was dominated by the Ardeidae family and had higher populations of birds and species richness when compared to the disturbed site. The undisturbed site had larger populations of fishes and more diverse compared to the disturbed site. The disturbed site had a higher forest density compared to the undisturbed. However, the undisturbed site was more diverse in mangrove species and also had a richer understory layer. The mangroves functioned as indirect food sources for the organisms living within the ecosystems, especially the fishes in both sites. As disturbances occur in a mangrove ecosystem, some species are able to adapt e.g. the *Pitangus lictor* (Lesser Kiskadee) in the disturbed site and the *Cichlasoma bimaculatum* (Black Acara) while others prefer undisturbed setting e.g. the *Fregata magnificens* (Magnificent Frigate bird).

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