Impacts of Coastal Agricultural activities on freshwater fish diversity in Guyana

Kalicharan L. *, Seecharran D.**

* Department of Biology, University of Guyana, Turkeyen, Georgetown, Guyana
**Department of Biology, University of Guyana, Turkeyen, Georgetown, Guyana

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Abstract– Studies on coastal biodiversity of agro-ecosystems in Guyana are limited. The agriculture sector contributes significantly to Guyana's economic growth and most of these agricultural activities are concentrated on the Low Coastal Plain of Guyana. This study assessed the impacts of agricultural activities mainly rice and sugarcane farming on freshwater fish diversity within Mahaicony and Enmore areas, located in Region 4 of Guyana's Coastal Plain. It was hypothesized that agricultural activities would adversely impact fish species diversity within the disturbed sites by lowering species richness and species evenness compared with undisturbed sites. In total, fourteen sites were sampled, where nine were disturbed and five undisturbed. For each site, the water quality parameters: Turbidity, Temperature, Dissolved Oxygen, pH, phosphate and Total Kjeldahl Nitrogen (TKN) were tested. Examination of 525 sampled fish species revealed a high taxonomic diversity. Fishes collected were distributed among 5 orders, 13 families and 25 genera. The Shannon – Wiener Diversity (H) Index showed that undisturbed sites had greater species diversity of 2.165 compared to disturbed sites at a value of 2.016. The Single Factor ANOVA tests proved that the statistical differences for species richness, species evenness and species diversity between disturbed and undisturbed sites were not significant. As such, agricultural activities have mild but no significant influences on fish diversity within the sampled disturbed sites when compared with the undisturbed sites.

Index terms– Agricultural activities, Coastal Biodiversity, Fish Diversity, Water Quality

I. INTRODUCTION

The Low Coastal Plain of Guyana lies on the northern edge of the country and is topographically flat and low-lying [1]. Though it accounts for 5% of the total land area of Guyana, it is inhabited by 90% of the country's population. This region is the center of economic activities in Guyana, where agriculture is one of the major sectors [1]. Because the low coastal region of Guyana is found to be rich in heavy fluvio-marine clays, it became the hub for significant economic agricultural activities mainly sugarcane and rice cultivation and cash-crop farming [1]. Apart from these, rearing of cattle and other livestock for food consumption is also common in this region [1]. The irrigation system to maintain such agriculture activities comes from natural waterways or by channels that have been dredged to provide that source of water, which in turn links to a natural source [1].

Agriculture is fundamental to Guyana's food security. In order to satisfy consumption, both locally and for export, the industry incorporates drastic means such as increase in pesticides and fertilizers use to surge production, and clearing and excavating of lands and waterways for better drainage and irrigation [1]. These activities ultimately threaten habitats and diversity of aquatic species. Fish species, like all other organisms, require healthy habitats to reproduce; grow and survive [2] and these agricultural activities may alter, damage or even destroy aquatic habitats and mostly importantly destroy fish populations some of which are still unknown to Guyana. As such, this research aimed to determine the freshwater fish diversity within disturbed sites highly impacted by agricultural activities (mainly sugarcane ad rice cultivation) and to ultimately compare that diversity with undisturbed sites that experience little to no impacts by such activities.

II. MATERIALS AND METHODS

- **Study Location**

Field samplings were conducted in two areas dominated by commercial cultivation of rice and sugarcane. The areas were Mahaicony, an area noted for commercial rice farming and Enmore, where sugarcane cultivation was commercially grown. In both areas, specific irrigation canals were selected for sampling which allowed for comparisons between fish species found in areas that are influenced by agricultural activities (classified as disturbed sites) and those found in sites that are more pristine or natural in nature (categorized as undisturbed sites).

- **Water Quality Assessments**

Water quality samplings were conducted at each site prior to the collection of fish species. Turbidity was measured using a Secchi disk to determine penetration of light of the water for each site. This was done at three different sections of each site: outer, middle and inner regions, providing that each region was accessible and the average depth was recorded in cm. Temperature readings were taken using a standard mercury thermometer submerged in the water body of each sampling site. Readings were taken at the outer, middle and inner sections of the sampling sites, providing that all were accessible. This procedure allowed for the comparisons of all three regions of each site where the average values were recorded.

Dissolved Oxygen (DO), pH, phosphates and TKN were analysed by an external laboratory, GUYSUCO INC. in Guyana. 300 millilitres (ml) of water samples were collected from the center region of each sampling site, labelled and placed into an icebox, which allowed for its integrity to be maintained. Subsequently, all the water samples were submitted to laboratory for analyses.

- **Fish Sampling**

Field sampling of fish diversity was done using drag seines. The use of drag seines allowed for complete sampling of each site which meant that every time a new species was caught in a drag, an additional of three drags were added to the total number of drags. This technique allowed for a more precise representation of the fish species in each sampling area since it increased the probabilities of exhausting all the species within that habitat. Species were collected from the drag seines and placed in a container with water for further processing. Where necessary, clove oil was utilised to euthanize live species.

- **Preparation, Storage and Identification of Fish Species**

Fish species collected for each site were transferred to an appropriately labelled container with 10% of formaldehyde that allowed for the specimens to be fixed and kept in streamlined positions. Subsequently, all samples were placed in labelled storage containers and 70% alcohol was added to each for preservation. All samples were kept under clean, dry and cool conditions in order for proper storage and preservation to be maintained. Identification was done by expert help and available publications. Verification of species was done at the Center of Study of Biodiversity (CSBD) at the University of Guyana where identified specimens was compared with the museum's collection. Also, species names were validated using FishBase.org.

III. RESULTS & DISCUSSION

A. Water Quality

Table 1: Mean Values obtained for Water Quality Parameters tested at Disturbed and Undisturbed Sites

Water Quality Parameter	Mean Value	
	Disturbed sites	Undisturbed sites
Turbidity (inches)	8.67 ± 4.69	7 ± 5
Temperature (°C)	30.44 ± 1.13	29.40 ± 0.55
Dissolved oxygen (mg/L)	2.47 ± 1.59	1.97 ± 1.29
pH	6.08 ± 0.77	6.26 ± 0.29
Phosphate (mg/L)	1.09 ± 1.99	0.23 ± 0.17
TKN	7.87 ± 8.20	4.06 ± 0.40

Turbidity described as a measure of light penetration is usually positively correlated with sediment erosion and in-stream production [3]. This study expected the waters for disturbed sites to be more turbid when compared with the undisturbed sites. As evident in Table 1, the data confirmed this expectation. The high turbidity for the disturbed sites can be attributed to high rates of sediment erosion [3] from the agricultural fields. However, there were no significant differences among the turbidity values obtained for both disturbed and undisturbed sites. This means that both sites had similar turbidity types.

Moreover, the concentration of dissolved oxygen in the water column measures aeration and photosynthetic activity [3]. For both disturbed and undisturbed sites there was no substantial difference between the mean values and standard deviation for this parameter (Table 1). We therefore suggest that aeration and photosynthetic activity for both sites are similar regardless of the varying impacts of agricultural activities.

pH measures the acidity or alkalinity of the water column. It was expected that the pH for the disturbed sites would be more acidic that undisturbed sites. This was projected for the disturbed sites since they were directly influenced by the run-off of fertilizers, pesticides and other agro-chemicals. However, the mean and SD values showed that there were no major differences between the pH of disturbed sites compared to undisturbed sites which was slightly acidic.

Data collected for water concentration of total phosphates and TKN showed significant differences between disturbed and undisturbed sites. Both phosphate and TKN concentrations were greater for disturbed sites compared to undisturbed sites. This was expected for disturbed sites since those water bodies were used to drain and irrigate agricultural fields, as such run-off of fertilizers and pesticides was expected to be more prevalent within such systems compared to undisturbed sites.

B. Species Diversity

A total of 311 individuals were sampled from the disturbed sites, while 241 were sampled from undisturbed sites. These individuals were distributed across 5 orders, 13 families and 25 genera. The species richness of the disturbed sites was calculated to be 18, while it was 22 for undisturbed sites. This was expected for the undisturbed sites on the premise that such areas are not heavily impacted by the agricultural activities as compared with the disturbed sites. A Single Factor ANOVA test showed no statistically significant difference (F (1,12) = 1.671, p = 0.22) in species richness for disturbed and undisturbed sites. In addition, lowered species evenness was expected for the disturbed sites due to impacts of agricultural activities within those areas. The species evenness (0.700) was greater for undisturbed sites when compared with disturbed sites (0.698). A Single Factor ANOVA test showed no statistically significant difference (F (1,12) = 0.170, p = 0.69) in species evenness for sampled species between the disturbed and undisturbed sites. This indicated that the species are distributed in similar proportions. Finally, the Shannon – Wiener Diversity Index was calculated for both disturbed and undisturbed sites. The index was calculated to be 2.165 for undisturbed, compared to an index of 2.016 for disturbed sites. This was expected for the undisturbed sites since there were moderate impacts of agricultural activities on those areas as compared with disturbed sites. A Single Factor ANOVA test confirmed that there was no statistically significant difference (F (1,12) = 0.303, p = 0.592) in species diversity between the disturbed and undisturbed sites.

The results of this study are similar to the findings of Jha, *et.al* (2009). When the distribution and abundance of fish species collected for that study were compared, it showed a clear sign of mild impact on the downstream of the rivers sampled. That indicated that the rapid increase in the use of agricultural inputs such synthetic fertilizers and pesticides has the potential to change the integrity of the rivers' channels [4]. For this study, the disturbed sites that were influenced by agricultural activities and inputs such as use of fertilizers and pesticides had high TKN and phosphates mean values which contributed to lower species richness, species evenness and species diversity when compared with the undisturbed sites. Additionally, the single factor ANOVA tests confirmed that there no statistically significant differences among the different variables: species richness, species evenness and species diversity between the disturbed and undisturbed sites. Therefore, using the variable species diversity as the indicator, it was found that agricultural activities had mild but no significant impacts on the fish species diversity for the disturbed sites compared with undisturbed sites.

IV. CONCLUSIONS

This study assessed the impacts of agricultural activities mainly rice and sugar-cane farming on fish diversity within Mahaicony and Enmore areas in Region 4 of Guyana's Coastal Plain. The results showed that the mean values for the parameters TKN and phosphate were higher for the disturbed sites compared with the undisturbed sites and contributed to the lower species richness, species evenness and species diversity of the disturbed sites having compared to undisturbed sites. The Single Factor ANOVA tests proved that the statistical differences for species richness, species evenness and species diversity between disturbed and undisturbed sites were not significant. As such, it can be concluded that agricultural activities have mild but no significant influences on fish diversity within the sampled disturbed sites when compared with the undisturbed sites.

REFERENCES

[1] Government of Guyana (GoG), "*Enabling activities for the preparation of Guyana's*". Georgetown. (2007).
[2] Jha, B., et al. "Study of Agricultural Impacts through fish base variables in different rivers". *Int. J. Environ. Sci. Tech,* 7(3), 2010, 609-615, http://www.bioline.org.br/pdf?st10060
[3] NOAA Habitat Conservation. (2010). "*What is Essential Fish Habitat*?" 2010. http://www.habitat.noaa.gov/protection/efh/index.html
[4] Uriarte, Maria., et al. "Influence of land use on water quality in a tropical landscape: A Multi-Scale Analysis". *Landsc Ecol,* 26(8), 2011, 1151–1164. doi: 10.1007/s10980-011-9642-y

AUTHORS

First Author – Leanna Kalicharan, Lecturer, Department of Biology, Faculty of Natural Sciences, University of Guyana, leanna.kalicharan@uog.edu.gy

Second Author – Diana Seecharran, Lecturer, Department of Biology, Faculty of Natural Sciences, University of Guyana, diana.seecharran@uog.edu.gy

Corresponding author – Leanna Kalicharan, leanna.kalicharan@uog.edu.gy, lkalicharan@yahoo.com, +592-688-1733.