Habitat study of *Sicydium* species at the Checkhall River

The correlation between velocity, depth, dissolved oxygen, and substrate in relation to Goby fish abundance

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Abstract

The influence of water velocity, depth, dissolved oxygen (DO), and substrate on the *Sicydium* goby fish species is rarely studied. The goal of this report was to obtain better information on the habitat of gobies and to supply a more comprehensive understanding of the environmental influences on the *Sicydium* species. In this research the overarching objective was to test the abundance of *Sicydium punctatum* and *Sicydium antillarum* gobies found in areas of varying velocity, depth, DO, and substrate types in the Checkhall River of the Commonwealth of Dominica.

*Keywords: *Sicydium Punctatum*, *Sicydium antillarum*, habitat, Checkhall River, Commonwealth of Dominica

Introduction

As information on the freshwater fishes of Dominica is very limited, this study sought to add to the collective knowledge of the freshwater fish in the area. The Checkhall River was selected as a research area based on the fact that it was readily accessible and densely populated with gobies of the genus *Sicydium*.

Sicydium gobies are in the family Gobiidae (Murdy and Hoese, 2004). Encompassing over 220 genera and 1500 species, Gobiidae is the largest family of fishes. Members of this family have successfully populated a variety of benthic environments, ranging from the bottoms of freshwater streams to shallow coral reefs and oceanic depths of 500m (Murdy and Hoese, 2004). Equatorial coral reefs are especially rich is various species of gobies (Murdy and Hoese, 2004).

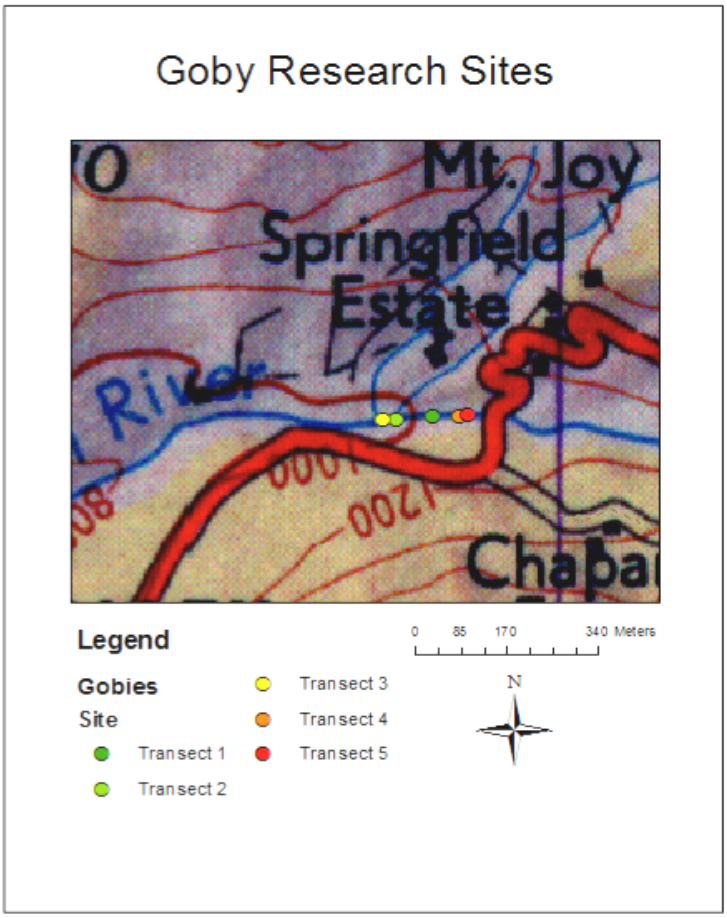
Many genera in the subfamily Sicydiinae are “juvenile-return anadromous” (Bell, 2009). This means that when the larval fish hatch, they are swept downstream and out to

sea to develop (Bell, 2009). After completing their larval stage, the juvenile fish return to the streams and may migrate upstream looking for suitable habitat, sometimes even scaling waterfalls (Bell, 2009). Additionally, Sicydiine gobies in the genus *Sicydium* are solely found in rainforest streams with fast-flowing currents that empty into oceans or seas (Watson, 2000). The adaptation that enables these gobies to climb upstream, even despite strong currents, is a ventral adhesive disc (Maie, 2007). This disc was formed after the pelvic fins of the gobies fused together (Maie, 2007).

In the streams of Dominica, there are three species of freshwater gobies in the subfamily Sicydiinae: *Sicydium plumieri*, *Sicydium punctatum* and *Sicydium antillarum* (Bell, et. al., 1995; Murdy, 2004). *S. punctatum* and *S. antillarum* so closely resemble each other that identification is usually only possible after collecting specimens (Bell, et. al., 1995). However, K.N.I. Bell, a prominent researcher of *S. punctatum* on Dominica, states that assessing the orientation of the vertical bars on lateral sides of their bodies can differentiate *S. punctatum* and *S. antillarum* (Bell et. al., 1995). The bars of *S. punctatum* cross, forming patters that look like the letters V, X, Y, or I, where as the bars of *S. antillarum* are vertical and parallel (Bell et. al., 1995). However, to obtain a definitive identification, other aspects of the specimen's anatomy should be examined. Additionally, gobies exhibit sexually

dimorphic coloration with females exhibiting a light brown body with darker brown bars and males, bright blue with dark bars (Bell, 2009).

In a paper published by Bell from the 2009 Symposium of the American Fisheries Society, he remarks that information on the habitats that Sicydiine gobies prefer will be important for conservation. This study was done with the objective of collecting data to clarify in which habitat they could be found most abundantly. Four stream traits were measured to describe the habitat: stream velocity, depth, percent of dissolved oxygen, and substrate type. Gobies were not collected for identification purposes, so it must be assumed that the data could include observations of both *S. punctatum* and *S. antillarum*. We hypothesized that the numbers of *Sicydium* species would be highest in slow-moving pools with rocky substrates to facilitate the use of their pelvic sucker disc.



Methods

Site Description

All goby data was taken from the Checkhall River near Springfield estate in the Commonwealth of Dominica, West Indies. Access to the stream was provided by a foot trail from the Archbold Tropical Research and Education Center

(ATREC). The stream is rocky with both fast flowing and pooling areas, and is surrounded by tropical rainforest. The river flows east to west into the Caribbean Sea and the research site is located at N 15.35° and W-61.37°.

Data Sampling

In order to determine the relationship of goby abundance to stream velocity, depth, dissolved oxygen, and substrate, five sampling sites along the Checkhall River were chosen. In order to obtain various areas of velocity and substrate data an area of the stream was chosen that had both pools and riffles, so the sandier substances could be found settled in the pooling areas and the large rocks and cobles in the faster flowing waters. With this in mind, five different sampling sites were chosen, so there were both riffles and eddies. Once the sites were chosen and marked with transect tape the area was then ready for the field investigation.

Each transect marker consisted of a rope several meters long with a plastic stake tied to each end. One of the stakes was marked with a #1. Also, the rope was marked with sharpie every meter from the #1 stake. At every sampling site, stake #1 was inserted into the left bank looking upstream at the edge of the water. The other stake was inserted across the stream, with the rope running perpendicular to the stream flow. If the rope was too long, the extra was rolled around the second stake so that the rope would stay taut across the water and the markings were visible every meter.

At every meter mark, readings for depth, dissolved oxygen, and stream velocity were taken in the late morning. Depth was measured with a long flexible measuring tape directly below the mark on the rope. One depth reading was taken and recorded for each meter mark along the rope. In order to record stream velocity a flow meter that counted

revolutions per minute with a small propeller was utilized. By holding the propeller midway between the surface and the bottom of the stream at each mark point an accurate estimation of stream velocity could be recorded. Timing each reading for a full minute gave the velocity readings in revolutions per minute which was later converted to meters per second. After disturbed sediment cleared the first goby count began at 12pm noon. The gobies within about a square meter were counted for each point. Unless the water was too shallow, all counts were taken with a face mask underwater. Also, stream bottom substrate (leafy, rocky, or sandy) was recorded at the marker points. After counts for each meter point were taken and recorded, we returned to the transect at 2 pm and 4 pm for repeats of our counts. On separate days, we used the Quanta system to record dissolved oxygen in stream water around 12 noon. To operate the Quanta, the sensor heads must be fully submerged in the water while the computer that displays the results must stay dry and be maintained above water. These two are connected with a long cord so that the display portion of the machine can stay with a person on dry land, while the reading device is taken out into the water. Readings from the water (the Quanta also provides temperature,

pH, velocity, salinity, etc) should be available within five minutes of submerging the sensor. We recorded dissolved oxygen in mg/L and also percent of dissolved oxygen for each marker point.

Overall, with 5 transects and several points on each, we ended up with 23 points of data which include depth, water velocity, dissolved oxygen, and goby counts for 12pm, 2pm, and 4pm. Pictures were also taken of each transect in order to record its exact situation in the stream.

After obtaining several pictures of the five transect sites an analysis was done to determine the substrate of each point on the transects. To simplify the categorization process the substrate was divided into three sections: leafy, sandy, or rocky. These sections were determined for a point if more than 50 percent of the ground cover was one of the three categories. The leafy category included everything that was living and dead organic plant matter. The sandy section included small to mid-sized grainy particles. The rocky category included everything from small to large boulders, cobles, and rocks. The results of all the combined data collected during the field and laboratory analysis is shown in the graphs below.

Results

Once obtaining the entire collection of data, the Goby counts were averaged and correlated to the velocity, depth, and dissolved oxygen and are presented below on **Figure 1**. The data below shows that the majority of Gobies were found at velocities of .05 to .1 meters per second, and in depths below .5 meters. There were fairly high amounts of dissolved oxygen found throughout the transects, so to have a better

indication of oxygen in the stream the percentage of dissolved oxygen was used and not the readings of mg/L.

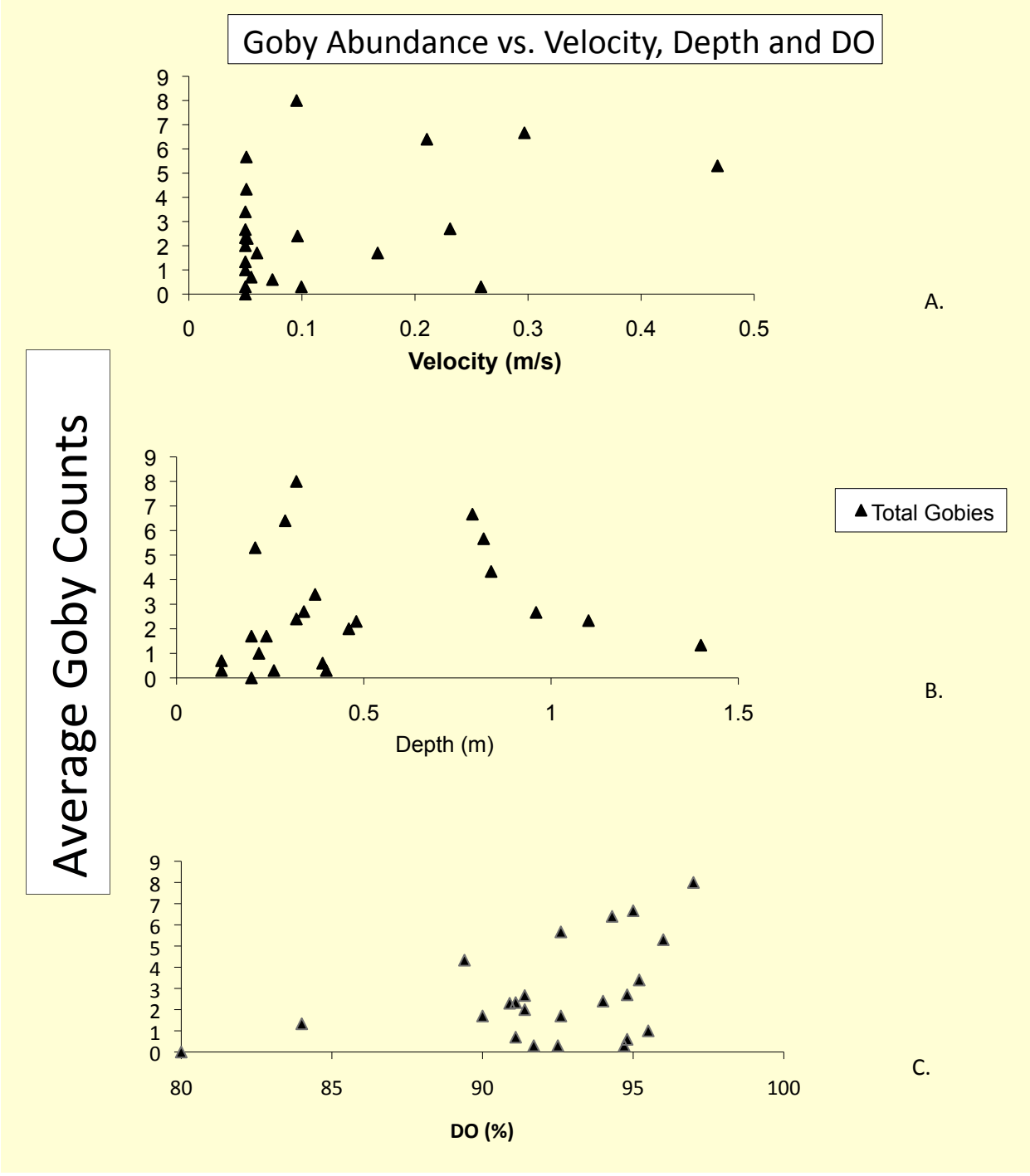


Figure 1: A. The relationship between velocity and gobies is shown in this scatter plot with very little correlation, B. the depth and gobies are also seen with little

correlation, C. The percent of dissolved oxygen is seen with a moderate correlation which is described later in the statistical results.

The three categories of substrate calculated as leafy, rocky, or sandy terrain further show the habitat in which Gobies were found in this study and are shown as an average in **Table 1** below.

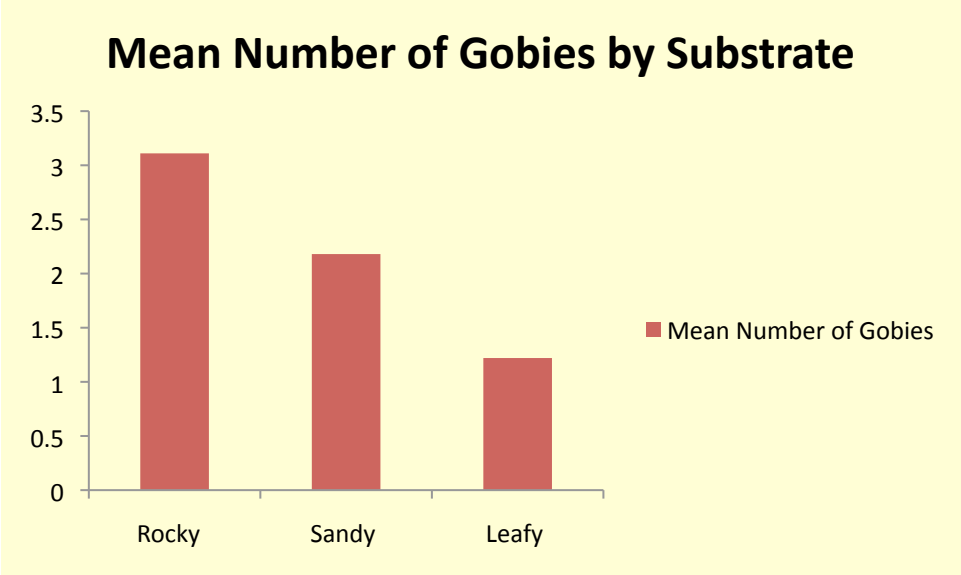


Table 1: The highest averages of gobies were found in the Rock substrate with the sandy and leafy showing a steady decline in means.

Velocity, Depth, and DO Statistical Analysis

In order to show the correlation between average Gobies and velocity, depth, and percentage of dissolved oxygen we used a Partial Correlation Test (the substrate correlation is calculated in a later test). This test holds all other variables constant while testing for each individual correlation in regards to Goby abundance. The null and alternative hypotheses for each of the three parameters tested are listed below:

1. Ho: the velocity and average number of Gobies are **not** significantly correlated.
   Ha: the velocity and average number of Gobies are significantly correlated..

2. Ho: the depth and average number of Gobies are **not** significantly correlated.
   Ha: the depth and average number of Gobies are significantly correlated.

3. Ho: the dissolved oxygen and average number of Gobies are **not** significantly correlated.
   Ha: the dissolved oxygen and average number of Gobies are significantly correlated.

Comparative Statistical Analysis Test		
	r value	**p-value**
Velocity	0.334	0.139
Depth	0.431	0.051
Dissolved Oxygen	0.442	0.045

Table 2: The Partial Correlation Analysis shows that when controlling for DO% and depth, velocity has a p-value of 0.139 and an r value of 0.334. When controlling for DO% and velocity, depth shows a p-value of 0.051 and an r value of 0.431. When controlling for velocity and depth, the DO% shows a p-value of 0.045 and an r value of 0.442.

Table 2 shows that the p-values for depth and velocity are all above .05 which is in the alpha level resulting from a 95% confidence interval. This means that we fail to reject the null hypotheses for these two variables, depth and velocity, and they are not significantly correlated to the average amount of Gobies. Although, the results above indicate that the p-value for depth, .051, is nearly within the 95% confidence interval, we still fail to reject the null hypothesis, therefore accepting that the depth has no significantly correlating data in relation to Goby abundance. Using the Comparative Statistical Analysis test we found that the only area of statistical significance was the percentage of dissolved oxygen compared to the average number of *Sicydium* species. The results showed that the DO% was below the p-value of .05 meaning we reject the null hypothesis, which indicates that DO and Goby readings are significantly correlated.

Substrate Statistical Analysis

A One-Way ANOVA was used to compare mean goby abundance across substrates. By using a One-Way Analysis of Variance (ANOVA), the data was tested for homogeneity with the variances (Levene's Test). Testing proved the variances were homogeneous, so

the ANOVA was utilized for the ground cover statistical analysis. The following null and alternative hypotheses show the areas that were tested.

4. Ho: the average number of Gobies does not differ among substrates.
   Ha: the average number of Gobies does differ among substrates.

The resulting ANOVA test proves that there is no significance between the different substrate groups and Goby abundance.

Table 3	Sum of Squares	Degrees of freedom	Mean Square	F	p-value	Sig.
Between Groups	10.322	2	5.161	.969		.397
Within Groups	106.525	20	5.326			
Total	116.847	22			0.383	

The most notable piece of data on **Table 3** is the p-value, .383, because the p-value is above .05, we fail to reject the null hypothesis which states that the substrate and the average number of Gobies are not significantly different at the 95% confidence interval.

Discussion

The resulting data shows that the original hypothesis stated above was not supported and that there is no correlation found between *Sicydium* species, substrate, or velocity. Because there of limited number of transects derived from the study area of the Checkhall River the resulting data did not have enough points to derive conclusive results in regards to the preferred velocity and substrate of *Sicydium* species. Although the average goby did prefer a rocky substrate in this study, the average was only 3.11, which is not a large enough sample size to state that the Sicydium species prefer rocky habitat. It was statistically shown that goby abundance was significantly correlated with dissolved oxygen. This result was expected because as aerobic organisms, it is assumed that gobies would prefer areas with abundant supplies of oxygen. Also, it should be noted that only areas high in oxygen would be able to support high numbers of gobies.

Further Studies

There were many constraints in this study that could have led to different results if time had allowed. Due to the limited number of transects no correlation between average goby species, velocity, depth, and substrate, were found. Although a slight correlation between gobies and dissolved oxygen were found, the accuracy of these results could be skewed by the small number of transect and human or technological error. Another constraint to this project was the rigorous amount of time needed throughout the day to collect samples on one transect. It may have been a better strategy to count gobies once a day as opposed to three times a day for one transect, so that more time could be devoted to multiple sites. Also at 4pm it was very difficult to collect data because much of the river was shaded by the lack of direct light and shadows from the trees, so it was harder to see the gobies. A good method of sampling would have been to set down a meter squared quadrate under each point on the transects. This would avoid double counting gobies and give more accurate results, however it may appear unnatural, so it may take a few days to a week for the gobies to be comfortable with this equipment. Further studies in this area with these suggestions could help to limit some of the inconclusive results derived in this research.

Conclusion

Overall this study has helped to produce a more comprehensive and collective understanding of the proper testing methods in determining the habitats of the *Sicydium* species of Gobies. Although some inconclusive data were derived, different results may have occurred if more samples were taken, or if the methods of sampling were more efficient.

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