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Diversity of the Ichthyofauna of Estuaries in Southeastern Trinidad

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ABSTRACT
Estuaries are highly productive aquatic systems. Five rivers in Guayaguayare Bay were sampled for fish by seining. During the survey, 25 species in 21 families representing eight orders were collected or observed. The most abundant species, *Mugil curema*, accounted for 56% of total catch. For the majority of species encountered, the size-frequency distributions revealed populations comprised largely of subadults and juveniles. Dissimilarity of inventories between sites may be related to a combination of biotic and abiotic factors. It is proposed that each species is maintained over the entire coastline by a series of incompletely independent populations and that these estuaries collectively represent one large metacommunity.

Key words: estuaries, fish fauna, metacommunity.

INTRODUCTION

An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea, and within which sea water is measurably diluted by fresh water derived from land drainage (Pritchard 1967). Estuaries are often associated with high rates of biological productivity due primarily to the *in situ* photosynthetic activity of phytoplankton, submerged vascular plants, periphyton, benthic algae, tidal marsh detritus, and land runoff, in decreasing order (Correll 1978). The nature of estuaries is such that they are able to trap productive bottom sediments carried in rivers and high levels of nutrients from land runoff (Correll 1978).

Fish communities that are located in estuaries are important to diverse groups such as scientific community, natural resource managers, and user groups. Fish communities that occur in estuarine environments can have their origin in marine or freshwater habitats and it is generally believed that the fish found in these areas are dominated by species that spawn at sea (McHugh 1967 in Berlatta-Bergana *et al.* 2002). Estuarine areas are utilized by the juveniles of marine species as it provides a safer environment for vulnerable larval stages. Hydrological events can play an important role in the temporal variation in densities of many fish taxa with the density of most early life and many juvenile stages being positively related to hydrological events (Morais and Morais 1994; Sylvie *et al.* 1999).

In traversing the coastline bounded by the Moruga River to the south and the Ortoire River to the east, one encounters the discharge points of many small to moderate drainages of quite similar overall topography. All of these streams are of rather gradual gradient, and drain mainly flat land under a varied mosaic of vegetation types from forest to cultivation and coastal shrub, mangrove and strand. None achieve the catchment area of the former-mentioned rivers.

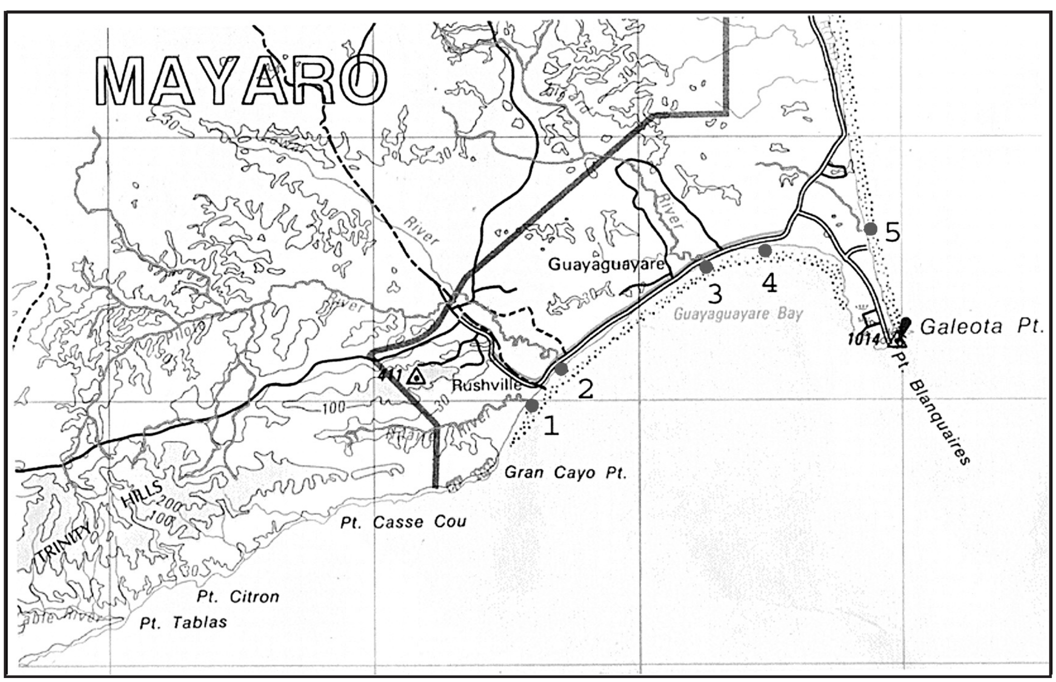

Fig. 1. Map of southeastern Trinidad showing five principal sampling sites.

Because of their low profile, flow is rather slow and the marine influences of tide and salinity tend to extend far inland resulting in well-developed estuarine habitats of untested, but purported high ecological importance. The present baseline study is located at this interface between marine and freshwater systems specifically in the vicinity of Guayaguayare Bay and Pt. Galeota.

Five river mouths (Fig.1) were sampled including those of the (1) St. Hilaire, (2) Pilote and (3) Lizard Rivers on the south coast. Two other unnamed streams were also investigated including (4) Stream A, on the south coast approximately one km east of Lizard; and (5) Stream B, located north of the Briko Air Services helipad on the east coast side of Pt. Galeota. Table 1 gives the UTM coordinates of these five sites along with the times and dates of sampling.

Site Descriptions

1. St. Hilaire River formed an almost enclosed, mangrove-lined lagoon during the rising tide. Sea conditions were fairly rough with the breakers bringing a considerable amount of sea-transported woody and other vegetative debris into the river via the 3 m wide channel. Upstream of this shallow, narrow channel the river attained a wider, deeper profile (approximately 10 m wide and up to 1.5 m deep).

2. Pilote River was the widest and deepest of all sites sampled. The tide was rising and, with fairly rough sea conditions, there was a strong landward tidal current coupled with considerable wave action. Floating mats of vegetation were quite commonly observed entering through the comparatively narrow beach channel (about 5 m wide) into the much wider (>25 m at widest point), deeper (>2 m at deepest point) sandy lagoon downstream of the bridge. All seining was done downstream of the bridge. Upstream of the bridge the river narrowed slightly and was lined with mangrove.

3. Lizard River was approximately 15 m wide and 1.5 m deep at the bridge. Mud/sand flats obtained on either side of the channel immediately upstream of the bridge and at the time of sampling (falling tide) turbid water could be seen entering the main river channel as the surrounding mangrove wetland drained. Downstream of the bridge the river narrowed to about 5 m and gradually became shallower as it flowed over the low-profile beach towards the sea.

4. The first unnamed river, Stream A, was accessed via a trail at the side of the road opposite the "Sit and Chat" Bar. At the time of sampling, the river mouth was almost completely blocked by a sand bar except for a very narrow (~1 m), shallow (~ 5 cm) channel. The actual depth was roughly 1 m within the sampling area. The surrounding vegetation was mainly secondary fringing forest, mangrove and *Bactris* palms.

5. The second unknown river, Stream B, was accessed via Pt. Galeota. From the car park near Briko Air Services helipad, the mouth of the river was accessed by walking to the beach and then north along the coast. This site was sampled at low tide and was almost completely blocked by a sand bar. At its widest point, the river was about 12 m wide and 1.5 m deep and lined with mangrove. There was no detectable flow.

METHODS

All sites were sampled using primarily a 10 m long river seine of mesh size ~ 0.5 cm. Two reaches of approximately 10 m in length were seined by pulling with the direction of the current (which varied between ebb and flow among the sites sampled) or toward the sandbank on the seaward end where there was no discernible flow. Further sampling was done using a long-handled landing net (mesh approximately 0.5 cm) in microhabitats not suited to seining, namely channel margins with undercut banks and amongst submerged and emergent vegetation.

All fish were counted and measured. In keeping with standard practice, total length (TL) was recorded. Easily identified species were counted *in situ* and returned live to the water. However, representative specimens of most species had to be kept for subsequent identification. These individuals were kept on ice and later preserved, using 70% ethanol. Subsequently they were identified using keys and descriptions, FAO (1978), Froese and Pauly (2006), Eshemeyer (1998), Perez-Farfante and Kensley (1997).

To incorporate a measure of evenness into the analysis

Table 1. List of sampling sites, times and coordinates.

Site #	Name	Date sampled	Sample time	Tide	GPS (UTM 20P)
1	St. Hilaire	8 Sep 06	1450 - 1540	rising	713093 E 1120180 N
2	Pilote	8 Sep 06	1320 - 1430	rising	713548 E 1120609 N
3	Lizard	8 Sep 06	0820 - 1000	falling	716404 E 1122843 N
4	Stream A	8 Sep 06	1010 - 1100	low	717405 E 1123109 N
5	Stream B	9 Sep 06	1000 - 1100	low	719497 E 1123382 N

of diversity for each site, Shannon's diversity index was calculated using the following formula:

$$H = -\sum_{i=1}^{s} p_i \; in \; p_i$$

where S = total number of species in the community;
p_i = the proportion of S made up by the *i*th species.

To get an understanding of site similarity, a matrix based on fourth-root transformed abundance was constructed using the Bray-Curtis measure (Bray and Curtis 1957). This and the subsequent cluster analysis (using group-average linkage) of sites was done using the PRIMER 5 software package, an updated windows-based version of PRIMER (Clarke and Warwick 1994).

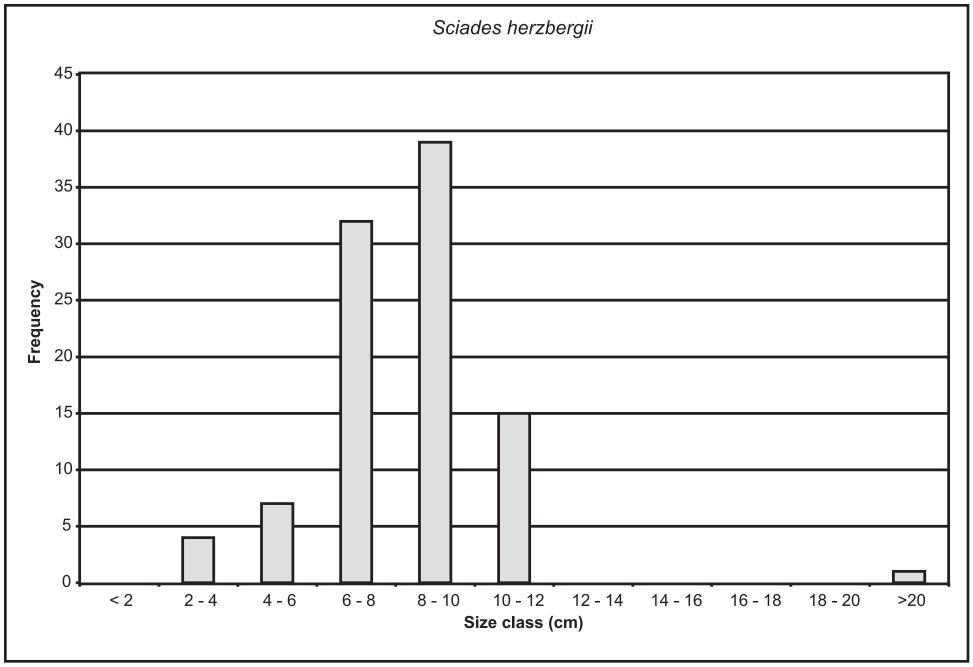

Fig. 2. Frequency-size distribution for all *Sciades herzbergii* caught at sampling sites.

RESULTS

During the survey, 25 species in 21 families representing eight orders were collected or observed (Table 2). Of these, only 9 species were found at more than one sample site. One species, *Selanaspis herzbergii*, was found at all five sample sites while two others (*Atherinella* sp. and *Mugil curema*) were found at four sites. Six species were found at two sites (*Trachinotus carolinus*, *Hyperoglyphe* sp., *Centropomus ensifurus*, *Polydactylus virginicus*, *Menticirrhus saxatilis* and *Trinectes inscriptus*).

The remaining species were either recorded at only one sample site (15) or subsequently observed in and around nearby estuarine habitats but not collected at the five principal sampling sites (the carangid fish *Trachinotus goodei*).

Site #4 had the highest species richness (12) and overall abundance (307 specimens, see Appendix 1) with the other sites having 6 to 9 species each and much lower overall abundance (67 - 205). Conversely, site # 4 scored

Table 2. List of species collected /observed at five principal sampling sites and with general collecting.

Order	Family	Species	Common name	Authority	Presence at site 1	2	3	4	5	General
Atheriniformes	Atherinopsidae	*Atherinella* sp.	baitfish, silverside		●	●	●	●		
Beloniformes	Hemiramphidae	*Hyporhamphus unifasciatus*	half beak, balaju	(Ranzani 1842)		●				
Clupeiformes	Pristigasteridae	*Odontognathus compressus*	herring	Meek & Hildebrand (1923)		●				
Cyprinodontiformes	Anablepidae	*Anableps anableps*	four-eyed fish	(Linnaeus 1758)					●	●
	Poeciliidae	*Micropoecilia picta*	swamp guppy, millions	(Regan 1913)			●			●
Elopiformes	Elopidae	*Elops saurus*	ladyfish, banane	Linnaeus (1766)				●		
	Megalopidae	*Megalops atlanticus*	grand-écaille, tarpon	Valenciennes (1847)				●		
Perciformes	Carangidae	*Trachinotus goodei*	palometa, pompano	Jordan & Evermann (1896)						●
		Trachinotus carolinus	pompano	(Linnaeus 1766)				●	●	
		Caranx crysos	carangue	(Mitchill 1815)	●					
	Centrolophidae	*Hyperoglyphe* sp.	ruff			●		●		●
	Centropomidae	*Centropomus pectinatus*	snook	Poey (1860)			●			
		Centropomus ensifurus	snook	Poey (1860)		●		●		
	Gobiidae	*Evorthodus lyricus*	goby	(Girard 1858)				●		
	Haemulidae	*Haemulon bonariense*	grunt	Cuvier (1830)			●			
	Lobotidae	*Lobotes surinamensis*	leaf fish (marine)	(Bloch 1790)		●				
	Lutjanidae	*Lutjanus griseus*	grey snapper	(Linnaeus 1758)			●			
		Lutjanus sp.	snappers						●	
	Mugilidae	*Mugil curema*	white mullet	Valenciennes (1836)	●	●		●	●	
	Polynemidae	*Polydactylus virginicus*	thread fin	(Linnaeus 1758)	●			●		
	Sciaenidae	*Menticirrhus saxatilis*	croaker	(Bloch & Schneider 1801)	●			●		
	Trichiuridae	*Trichiurus lepturus*	cutlassfish	Linnaeus (1758)			●			
Pleuronectiformes	Achiridae	*Trinectes inscriptus*	flatfish	(Gosse 1851)				●	●	
	Paralichthydae	*Cyclopsetta chittendeni*	left eyed flounder	Bean (1895)		●				
Siluriformes	Ariidae	*Selanaspis herzbergii*	catfish	(Bloch 1794)	●	●	●	●	●	
				Total species	6	9	7	12	6	4
				H	1.161	1.401	1.350	1.018	1.084	

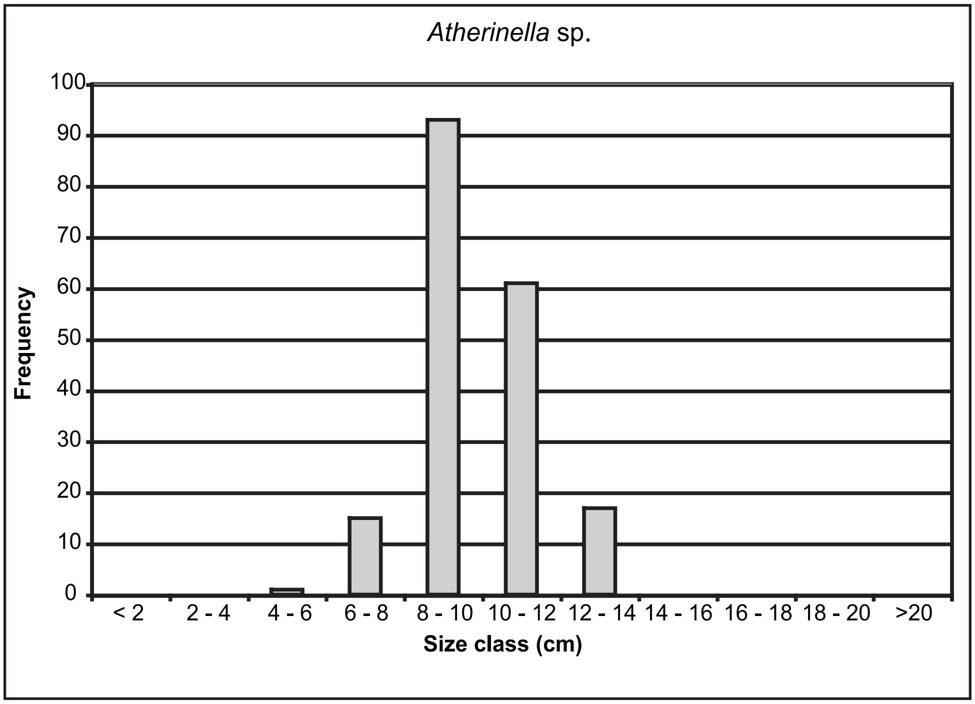

Fig. 3. Frequency-size distribution for all *Atherinella* sp. caught at sampling sites.

the lowest Shannon index (1.018), with site #2 scoring the highest (1.401).

Sites #1 and #5 each had only one unique species (only caught at that one site) while all other sites had three or four unique species. These accounted for 17%, 44%, 57%, 25%, 44% and 17% of the inventories of sites #1 - 5 respectively.

The only species common to all sites, *Selanaspis herzbergii,* had an approximately normal size distribution (Figure 2) with a mode at 8-10 cm. Of the two other common species (caught at minimum of 4 sites) *Atherinella* sp. (with a modal size of 8-10 cm, see Figure 3) has a continuous size distribution; while there is a distinctly disjunct distribution for *Mugil curema* (Figure 4).

This last species was not only very common, but also the most abundant with 475 individuals caught (56% of total catch) and was the most dominant species where present. *Atherinella* sp. was the most abundant species at site #3 and the second most abundant overall with 162 individuals caught (19% of total catch). The next most abundant species include the ubiquitous *S. herzbergii* (80 individuals, 9% of total catch) and *Menticirrhus saxatilis* (two sites, 44 individuals, 5% of total catch).

In the cluster analysis the Lizard River site separates out first at about 28% similarity (Figure 5). Of the remaining sites, Stream B separates next at about 41%. This is followed by Pilote, which is 53% similar to the remaining two sites. St. Hilaire and Stream A are the two most similar sites at about 61%.

All species caught have been recorded from inshore or brackish waters within the Western Central Atlantic and Caribbean fishing area (Froese and Pauly 2006) with no purely freshwater species represented. Important commercial and artisanal fisheries are based on many of the fish species caught.

DISCUSSION

The fact that these catchment areas are only very sparsely inhabited suggests minimal land-based anthropogenic impact on the estuarine communities. Assuming this to be true, and that marine based pollution/disturbance is not a major factor, the inventories produced herein would be representative of the natural communities that exist in

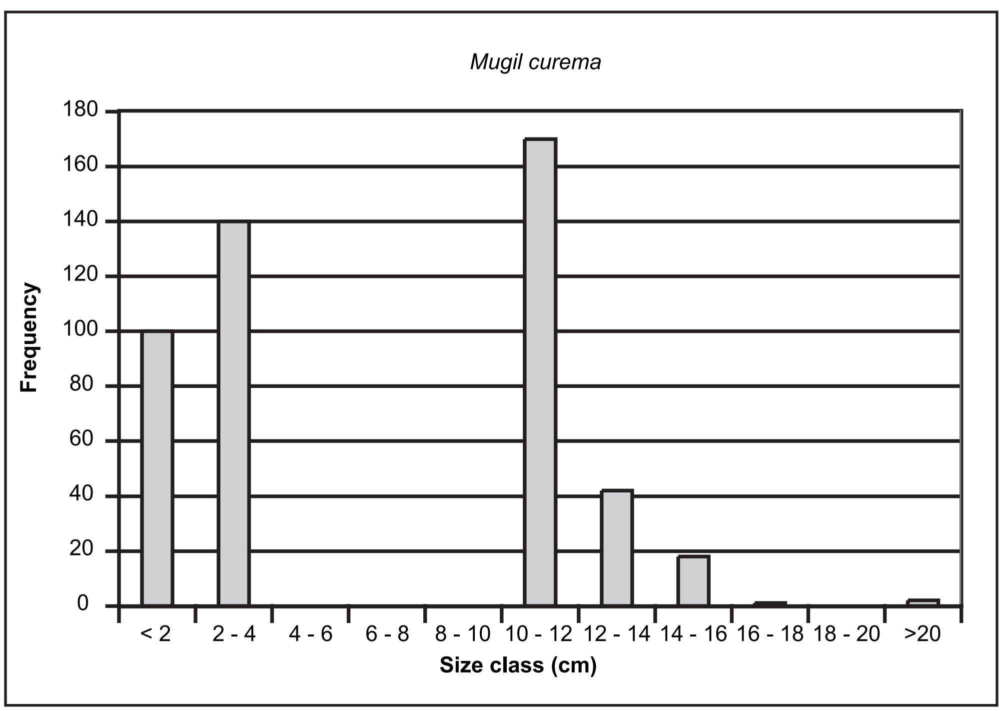

Fig. 4. Frequency-size distribution for all *Mugil curema* caught at sampling sites.

coastal estuaries of the southeast coast.

For the majority of species encountered, the size-frequency distributions revealed populations comprised largely of subadults and juveniles (comparing size ranges caught to maximum sizes listed in Froese and Pauly {2006}). Of the two large *M. curema* captured at site #2 (Pilote), it was discovered that one of two individuals was a mature female that was gravid. These observations indicate the importance of these habitats as nurseries, where some marine species spawn and undergo early development. For other species, juveniles may move between these habitats and the sandy nearshore environment depending on the tide and availability of food.

While the total species count was fairly impressive, each individual site was less so, with the majority of species restricted to one site. *Mugil curema* proved to be quite dominant overall and at each individual site. In fact, the second highest evenness (as shown by the Shannon diversity index), occured at site #3 (Lizard) where this species was not caught. The presence of the large predatory *Trichiurus lepturus* at this site may account for the absence of the highly mobile *M. curema*. On inspection of the gut contents of the predator, remains of several *M. curema* were found, lending credence to this explanation. It is the unique presence of this predator and absence of the prey species in the samples collected at this site that largely account for its highest dissimilarity in the cluster analysis.

The populations found within each small estuarine habitat are more than likely connected via dispersal especially since the majority of the species encountered are either primarily marine or frequently move between the marine and estuarine environment. As such, each species is maintained over the entire coastline by a series of incompletely independent populations, which together can be termed metapopulations (Levin 1969; Hanski and Simberloff 1997; Hanski 1997; Harrison and Taylor 1997; Cronin 2003).

Small estuarine habitats are very dynamic in physical and chemical nature, with current, depth, salinity, turbidity and dissolved oxygen regularly varying on a daily basis. The fact that site #4 (Stream A) had the highest species richness may be a result of the comparatively closed nature of the lagoon found and the small size of the catchment (the stream does not even appear on the map) as these would presumably result in a more stable environment. This may not always be, as tidal regimes change over each month, sea conditions and/or high rainfall can breach sand bars. High rainfall may also significantly alter salinities within the lagoon.

Commonly, daily physical and chemical variation in estuaries produces a particularly demanding environment that has profound effects on biological communities. The first and most intuitive effect is that individual species must either have a wide range of tolerances or else undergo significant daily migration to maintain themselves within suitable niche-space. Even for the species that have wide tolerance ranges, e.g. the euryhaline *Selanaspis herzbergii*, localized populations may undergo quite drastic fluctuations as they are exposed to varying immigration, emigration and extirpation of populations of competitors, prey and predators. It is therefore not surprising that the inventories at the five sites are so different from one another.

The importance of each small estuarine habitat does not necessarily lie in this perceived uniqueness. In fact, if these sites were sampled over a time series that incorporated season it might be expected that the integrated lists would be quite similar. Rather, one should view these small habitats within a larger framework in which local communities are linked by dispersal of individuals of their constituent species i.e. the metacommunity (Holyoak *et al.* 2005).

Thus while localized communities may exhibit quite variable dynamics, the tendency is for the metacommunity to be quite stable and sustained by the combined effects of its many constituent communities. If this interconnectedness on the large scale (over the entire coastline or nearshore ecosystem) is considered, the importance of each small part (community) in stabilizing the whole

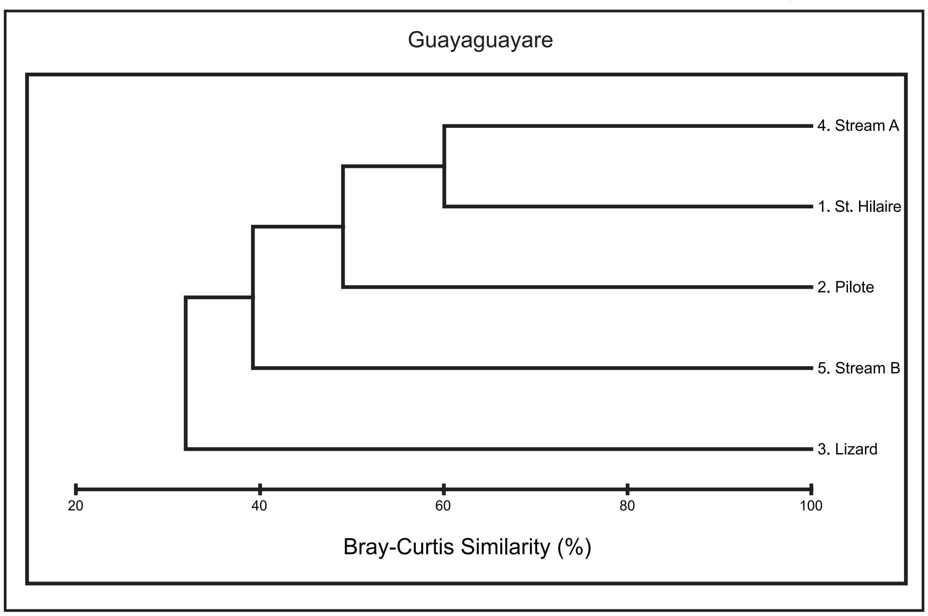

Fig. 5. Dendrogram showing hierarchical clustering of sampling sites using Bray-Curtis similarity (%).

(metacommunity) cannot be discounted.

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Appendix 1. Raw size-frequency data collected from each site.

Site	Species	Size classes (cm)											Totals	
		< 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12	12 - 14	14 - 16	16 - 18	18 - 20	>20	by species	for site
(1) St. Hilaire	*Atherinella* sp.				4	37	8	14					63	
	Caranx crysos			1									1	
	Menticirrhus saxatilis				2	1	1	1		2	1		8	
	Mugil curema	40	60										100	
	Polydactylus virginicus				1	1	1						3	
	Selanaspis herzbergii				12	17	1						30	205
(2) Pilote	*Atherinella* sp.				8	2	38	2					50	
	Centropomus ensiferus					1	2						3	
	Cyclopsetta chittendeni		1										1	
	Hyperoglyphe sp.	4											4	
	Hyporhamphus unifasciatus									5			5	
	Lobotes surinamensis				1	1							2	
	Mugil curema	20	40				2	3				2	67	
	Odontognathus compressus		1	2									3	
	Selanaspis herzbergii			4	8	1							13	148
(3) Lizard	*Atherinella* sp.			1	3	24	5	1					34	
	Centropomus pectinatus			1	1	6	5						13	
	Haemulon bonariense							1					1	
	Lutjanus griseus					1	1						2	
	Micropoecilia picta		3										3	
	Selanaspis herzbergii				6	4	2					1	13	
	Trichiurus lepturus											1	1	67
(4) Stream A	*Atherinella* sp.					12	1						13	
	Centropomus ensiferus	2	1	2									5	
	Elops saurus							1					1	
	Evorthodus lyricus				6								6	
	Hyperoglyphe sp.	4											4	
	Megalops atlanticus											1	1	
	Menticirrhus saxatilis			8	12	16							36	
	Mugil curema		2				168	39	18	1			228	
	Polydactylus virginicus			2									2	
	Selanaspis herzbergii		4	3	2								9	
	Trachinotus carolinus			1									1	
	Trinectes inscriptus		1										1	307
(5) Stream B	*Anableps anableps*					1	1						2	
	Lutjanus sp.	20											20	
	Mugil curema	40	20										60	
	Selanaspis herzbergii				4	8	3						15	
	Trachinotus carolinus			1									1	
	Trinectes inscriptus		1										1	99
	Totals	130	134	26	70	133	239	62	18	8	1	5	826	826