

**Summary of Fisheries Assistance Project:
Rio Mameyes Survey, Caribbean National Forest, April 2005**



**United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1650 Ramble Rd.
Blacksburg, VA 24060-6349**

C. Andrew Dolloff, Project Leader

**Report prepared by:
Dan Nuckols and Craig Roghair
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Introduction

Variations of the basinwide visual estimation technique (BVET) fish and habitat inventories have been used to quantify stream habitat and fauna in the Caribbean National Forest (CNF) since 1992 (Stoll et al. 1992, Leftwich and Dolloff 1997, Roghair et al. 2000 & 2001). These inventories provided valuable information to the CNF, however limitations in staffing and funding prevent the Forest from implementing a long-term Forest-wide monitoring program. In 2002 the Center for Aquatic Technology Transfer (CATT), in coordination with the CNF, Southern Research Station scientists, and Southern Region staff, developed an aquatic monitoring program that allowed comparison of results from earlier BVET inventories (Roghair and Dolloff 2002).

In 2005, the CNF asked the CATT to provide personnel to assist with implementation of the long-term monitoring program on Rio Mameyes. Rio Mameyes is one of the most pristine rivers in Puerto Rico and in addition to providing a source of fresh water, tourism associated with the river provides considerable economic benefits to the local economy (Caban and Loomis 1999). In April 2005, we assisted CNF personnel with inventories for freshwater shrimp and crab and associated habitat data. The survey was the first using this methodology on Rio Mameyes and provides the CNF with data for comparison to other CNF streams and to examine for changes in Rio Mameyes over time.

Inventory Area

We accessed Rio Mameyes on private land near Colinas del Yunque, approximately 1.5 km upstream from the confluence with Quebrada Anon (Figure 1). The survey continued upstream for approximately 7 km ending just downstream from the confluence with Quebrada La Coca.

Methods

We collected data for aquatic fauna and habitat using methods described in the CNF long-term aquatics program (Roghair and Dolloff 2002). To begin the survey we selected a random number between 1 and 10, indicating the first habitat unit for both fast (riffle, run or cascade) and slow (pool or glide) water where diver counts and habitat measurement would be performed. We then entered the water at the downstream end of the survey reach and walked upstream counting the total number of fast (hereafter referred to as riffles) and slow (hereafter referred to as pools) water habitat units we encountered. When we reached the randomly selected number for riffles and pools we performed a diver count and measured several habitat attributes. We then continued upstream, performing diver counts and measuring habitat attributes in every 10th riffle and 10th pool.

Aquatic Fauna

We inventoried aquatic fauna in Rio Mameyes by performing diver counts in approximately 10% of pools and riffles encountered. One to three divers were used depending on habitat unit size. The diver(s) entered the selected habitat units and proceeded slowly upstream while searching for and counting all individuals of each species. It was often necessary to turn over substrate particles to count

hidden shrimp, crab, and fish. Diver counts were used to examine the distribution and relative abundance of each species. Relative abundance and densities were summarized from data using Excel spreadsheets and graphs were produced using SigmaPlot software.

Habitat

At every dive unit we counted the total pieces of large woody debris (LWD), visually estimated the dominant and subdominant substrate particle sizes, and measured the habitat unit length, wetted channel width, average and maximum water depths, gradient (riffles only), and canopy cover. All LWD within the active channel that were greater than 1.0 m in length and 10 cm in diameter were classified (Table 1) and counted. The substrate size class (Table 2) that covered the greatest amount of surface area in the habitat unit was declared the dominant substrate. The subdominant substrate covered the second greatest amount of surface area. Unit lengths and wetted widths were measured to the nearest meter with a meter tape. Depths were measured to the nearest 1.0 cm by taking depth measurements with a graduated staff at various places across the channel profile within each habitat unit. Gradient was measured with a clinometer from the upstream to the downstream extent of riffles. Canopy closure was measured with a convex spherical densiometer while standing in the center of the habitat unit. We were unable to collect GPS data due to thick cloud and canopy cover or elevation data due to equipment malfunction. Data were summarized using Excel spreadsheets and graphs were produced using SigmaPlot software.

Results

Aquatic Fauna

We sampled 11 % of pools (n=20) and 10 % of riffles (n=17) in the 6.8 km stream reach. Habitat units were typically moderate in size requiring two divers. However, on one occasion (pool 133) three divers were used. In total, we identified seven shrimp species (*Xiphocaris elongata*, *Atya scabra*, *Micratya poeyi*, *Macrobrachium faustinum*, *Macrobrachium heterchirus*, *Macrobrachium carcinus*, and *Macrobrachium crenulatum*), one crab species (*Epilobocera sinuatifrons*), and five fish species (*Sicydium plumieri*, *Awaous banana*, *Agonostomus monticola*, *Anguilla rostrata*, and *Gobiomorus dormitor*).

X. elongata and *M. faustinum* were the most widespread and commonly encountered shrimp species. *X. elongata* were more frequently encountered than all other species of shrimp (Figure 6). *M. carcinus* were encountered sporadically throughout the reach (relative abundance = 3.1%, n = 7). We encountered only one *M. crenulatum* (pool 133) and two *M. heterochirus* (riffle 33 and 123). Relative abundance for shrimp and crab species ranged from 66 % (n=150) for *X. elongata* to 0.4% (n=1) for *M. crenulatum*. *Sicydium plumieri* and *A. monticola* were the most frequently encountered fish species (Figure 6). Relative abundance for fish species ranged from 64 % (n=1663) for *S. plumieri* to 0.8 % (n=20) for *A. rostrata*.

Habitat

We encountered 185 pools, 2 glides, and 169 riffles in the 6.8 km inventory reach of Rio Mameyes. The total surface area of pools where we performed diver counts and habitat measurements was 2786 m² and 1145 m² for riffles. The wetted width ranged of pools ranged from 3 m to 18 m with an average of 8.3 m, and riffles ranged from 2.8 m to 16.9 m with an average of 6.5 m (Figure 1).

Maximum pool depths in Rio Mameyes ranged from 70 cm to 230 cm, with a median of 105 cm and maximum riffle depths ranged from 32 cm to 90 cm, with a median of 75 cm. Average pool depths ranged from 40 cm to 100 cm, with a median of 60 cm and average riffle depths ranged from 20 cm to 50 cm, with a median of 45 cm (Figure 2).

The most frequently encountered substrate types in the surveyed reach of Rio Mameyes were boulder and large gravel. Boulder was the dominant substrate in 50% of pools and 61% of riffles. Large gravel was the dominant substrate in 30% of pools and 11% of riffles. The most common subdominant substrates in pools were large gravel and boulders, whereas cobble was the most common subdominant substrate in riffles (Figure 3).

Only four pieces of large woody debris (LWD) were tallied for 20 pools and 17 riffles we inventoried. We encountered a single piece of LWD sized <5 m in length with diameter 5-10 cm, two pieces >5 m with diameter of 11-50 cm, and a single rootwad (Figure 4).

Canopy closure ranged from near 0.25 to 24% and generally increased as we moved upstream (Figure 5). The average slope was 4.7 % and ranged from 2 to 16 % in riffle areas (Figure 5).

Discussion

Aquatic Fauna

We encountered a total of 7 species of shrimp, 5 species of fish and 1 species of crab. Most species were scattered throughout the entire survey reach as we did not encounter any major impediments to movement, man-made or natural, within the stream channel. The reach was relatively low gradient and low in elevation when compared to other streams we have inventoried in the CNF. Our inventory reach began at approximately 30 m elevation and ended at approximately 170 m. Elevations for inventories performed on Quebrada Jimenez (Leftwich and Dolloff 1997), Rio Icacos (Roghair et al. 2001), and Rio Gurabo (Roghair et al. 2000) were greater than those encountered on Rio Mameyes. Comparisons of distribution and density results between our Quebrada Jimenez, Rio Icacos, or Rio Mameyes inventories and the present inventory are not appropriate given changes in fauna and habitat associated with increasing stream elevation (Covich et al. 1996, March et al. 2002). However, our February 2001 survey on Rio Espiritu Santo did yield comparable data.

Our survey on Rio Espiritu Santo began at approximately 80 m elevation and stayed below 170 m elevation until the confluence with Quebrada Sonadora, 1300 m upstream of the survey starting point. *X. elongata* was the most common shrimp species and *S. plumieri* the most common fish species in both Rio

Mameyes and the first 1300 m of Rio Espiritu Santo. Furthermore, both species were found at similar densities; less than 50/100 m² for *X. elongata* and less than 500/100 m² for *S. plumieri*. *M. faustinum* was the most common *Macrobrachium* species encountered, however densities were lower in Rio Mameyes (< 10/100m²) than Rio Espiritu Santo (< 30/100 m²). *M. carcinus* were widely scattered at low densities in both streams. The fish species *A. monticola* was found at higher densities in Rio Mamayes (< 50/100 m²) than Rio Espiritu Santo (<10/100 m²). Species absent from the first 1300 m of Rio Espiritu Santo include the shrimp species *M. crenulatum*, the crab species *E. sinuatifrons*, and the fish species *G. dormitor*. *X. elongata* increase in density and *A. lanipes* are present in Rio Espiritu Santo after gradient and elevation increase, limiting the upstream distribution of fish predators such as *A. monticola* and *A. rostrata* (March et al. 2002). Similar changes in fauna may occur in Rio Mameyes upstream of Quebrada La Coca, where gradient and elevation increase rapidly.

Habitat

As we progressed upstream from a mix of private and CNF managed lands at low elevations to primarily CNF managed lands at higher elevations we saw corresponding increases in canopy cover and channel gradient. Canopy cover increased as we moved away from areas with active agriculture with greater wetted widths into Forested areas with decreased wetted widths. Channel gradient averaged less than 5% over the inventory reach and no major waterfalls that would affect fish or shrimp distribution were encountered.

Large woody debris (LWD) was almost non-existent in the habitat units in which we collected data. Pyron et al. (1999) found no relationship between amount of woody debris and density of predatory (*Macrobrachium spp.*) shrimp species, while *X. elongata* and *Atya lanipes* actually decreased in density with LWD additions. Most LWD likely washes out of the active stream channel during flash flood events that are common throughout the CNF. Pyron et al. (1999) hypothesized that the spaces between boulder and cobble substrates common in Rio Mameyes provide sufficient structure and cover for shrimp species.

Differences in inventory techniques between this and previous inventories performed by CATT make comparison of habitat results difficult. For example, in the present inventory we only counted LWD in habitat units in which we performed diver counts, resulting in a total of only 4 pieces of LWD. Previous inventories counted LWD in every habitat unit throughout the reach, providing information on the total amount of LWD per km (Roghair et al. 2000, Roghair et al. 2001), however it was decided that this approach was too labor intensive to be used as a monitoring technique on the Forest (Roghair and Dolloff 2002). The habitat data collected here is intended to document major changes in habitat attributes that may help to explain the distribution and abundance of shrimp and fish species throughout the course of the survey.

Summary

This inventory provides the CNF with important monitoring information that they can compare between streams on the Forest or within the same stream as inventories are repeated over time. The inventory should be continued upstream of Quebrada La Coca to document the distribution and abundance of shrimp in higher elevation reaches of Rio Mameyes. In addition, annual stream monitoring should continue on other streams within the CNF as described in Roghair and Dolloff (2002).. We recommend the CNF use two primary techniques to assess their aquatic resources, 1) streamwide surveys, which will provide information on the distribution and relative abundance of shrimp, fish, and crab species and habitat conditions in CNF streams, and 2) electrofishing surveys, which will provide information on the size class structures of fish, shrimp, and crab species at long-term monitoring sites. The results of past inventories and discussions with CNF suggest that with typical funding and staffing levels the CNF should be able to complete at least one streamwide inventory and several electrofishing surveys annually.

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Table 1. LWD categories used during Rio Mameyes inventory, April 2005.

Category	Length (m)	Diameter (cm)
1	<5	5-10
2	<5	11-50
3	<5	>50
4	>5	5-10
5	>5	11-50
6	>5	>50
7	rootwad	rootwad

Table 2. Substrate categories used during Rio Mameyes inventory, April 2005

Type	Number	Size
Organic matter	1	Leaves, detritus, etc.
Clay	2	Sticky, holds form when rolled into a ball
Silt	3	Slippery, does not hold form when rolled into a ball
Sand	4	Silt – 2 mm, gritty does not hold form when rolled into a ball
Small gravel	5	3 – 16 mm, sand to fingernail
Large gravel	6	17 – 64 mm, fingernail to fist
Cobble	7	65 – 256 mm, fist to head
Boulder	8	> 256 mm, bigger than head
Bedrock	9	

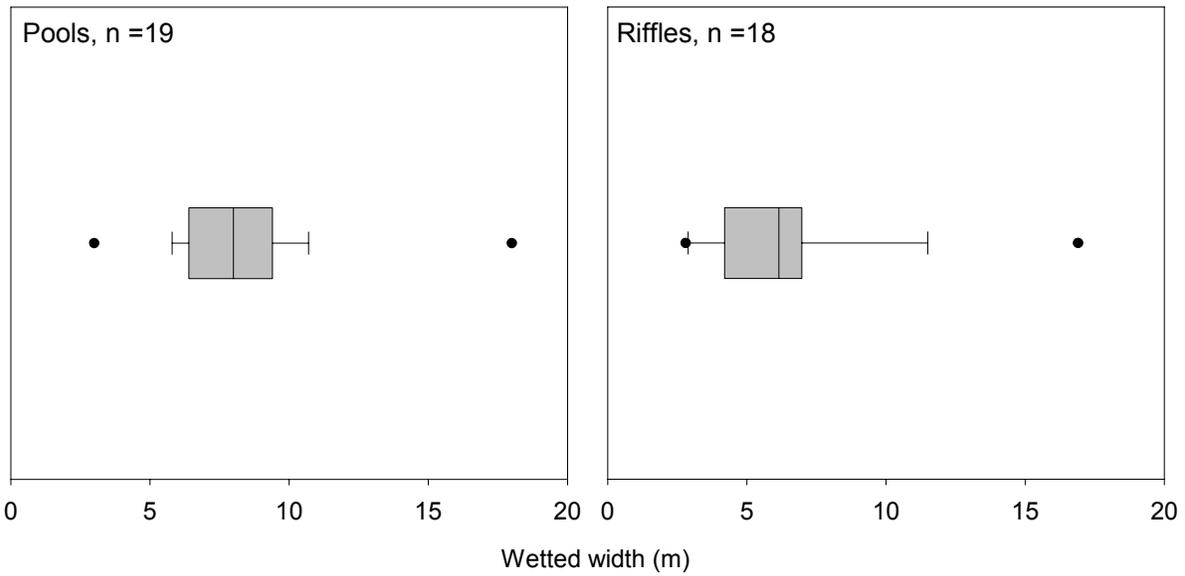


Figure 2. Wetted width of pools and riffles in Rio Mameyes, April 2005.

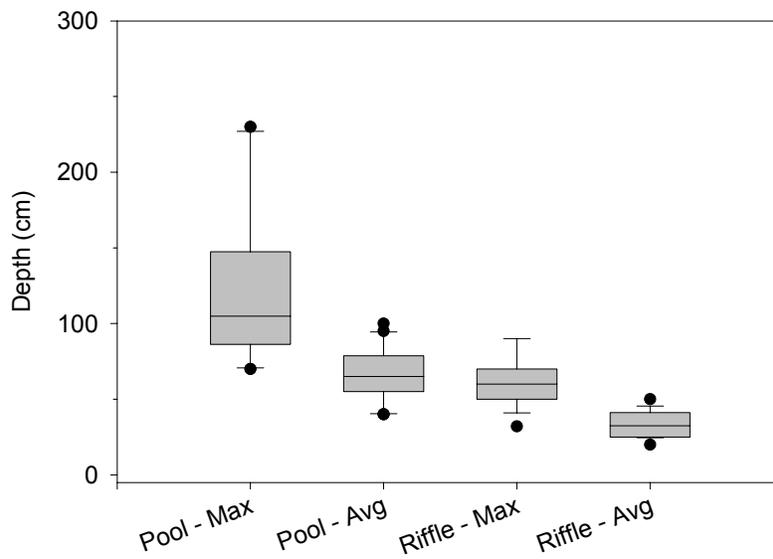


Figure 3. Water depths for pools (n=20) and riffles (n=17) in Rio Mameyes, April 2005.

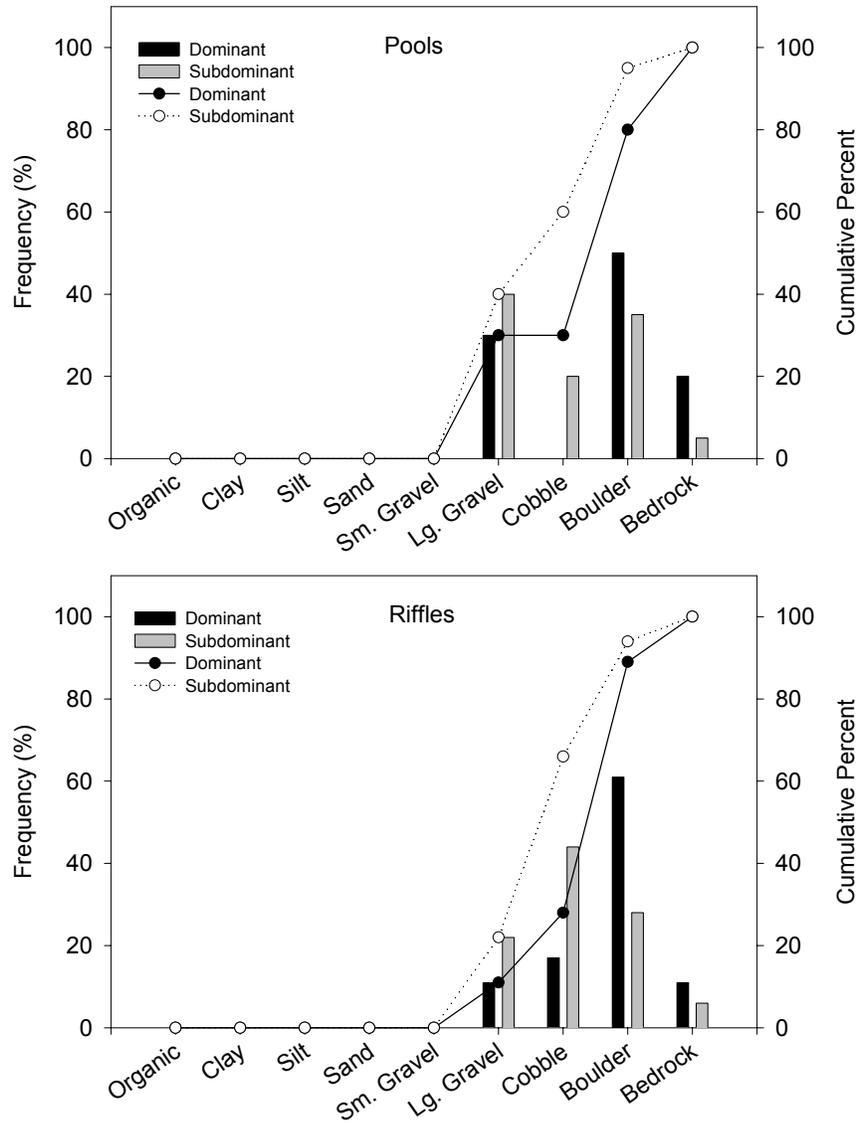


Figure 4. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence for pools (n=20) and riffles (n=17) in Rio Mameyes, April 2005.

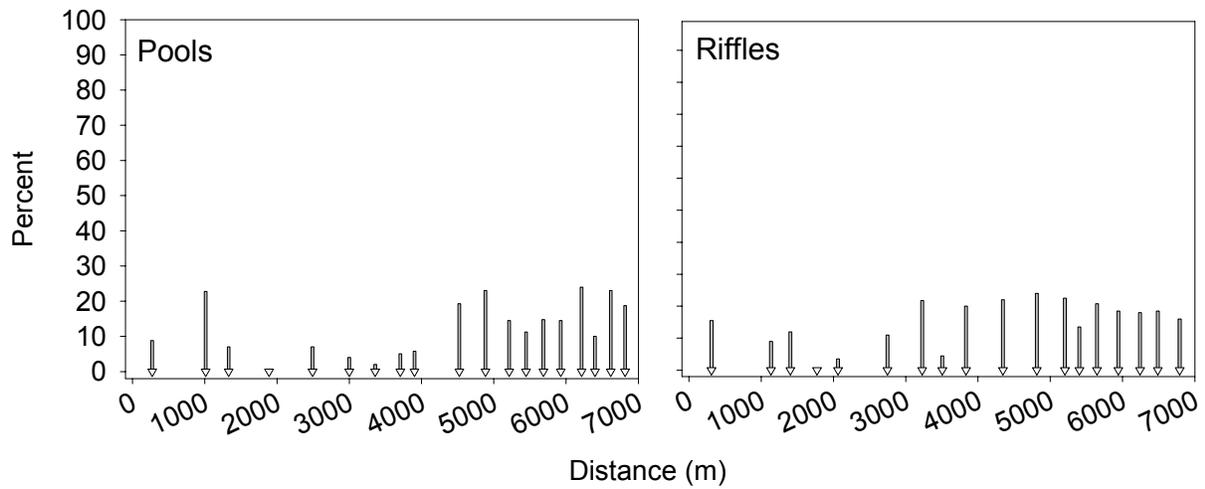


Figure 5. Percent of stream channel covered by tree canopy in Rio Mameyes, April 2005. Open triangles indicate location of measurements.

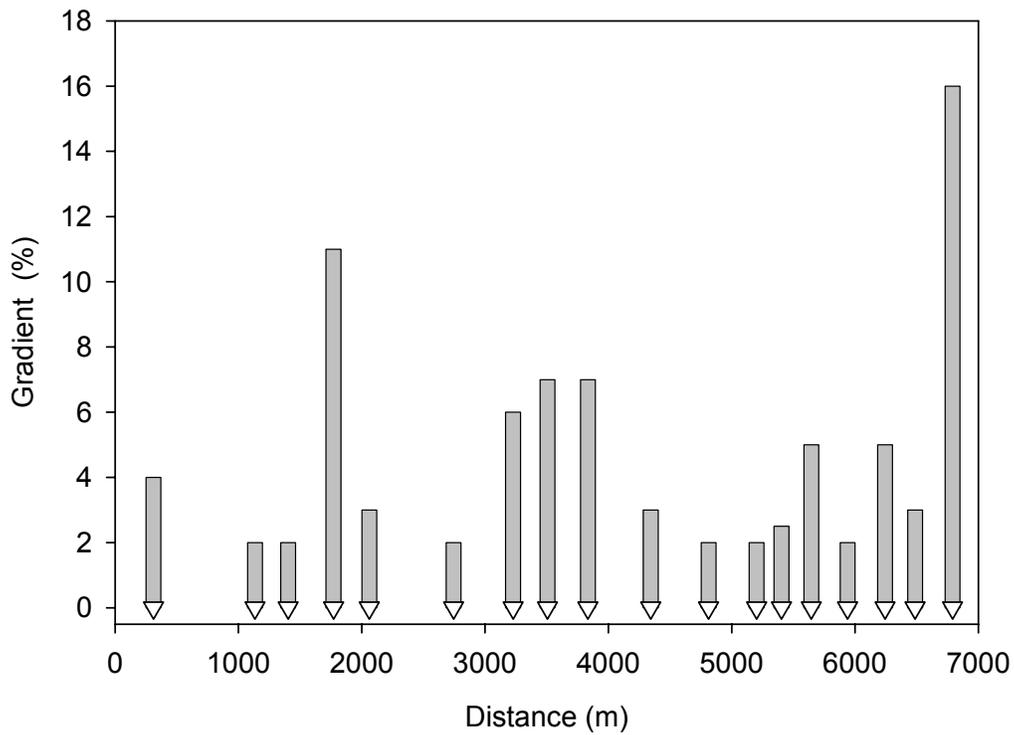


Figure 6. Gradient of riffles in Rio Mameyes, April 2005. Open triangles indicate location of measurements.

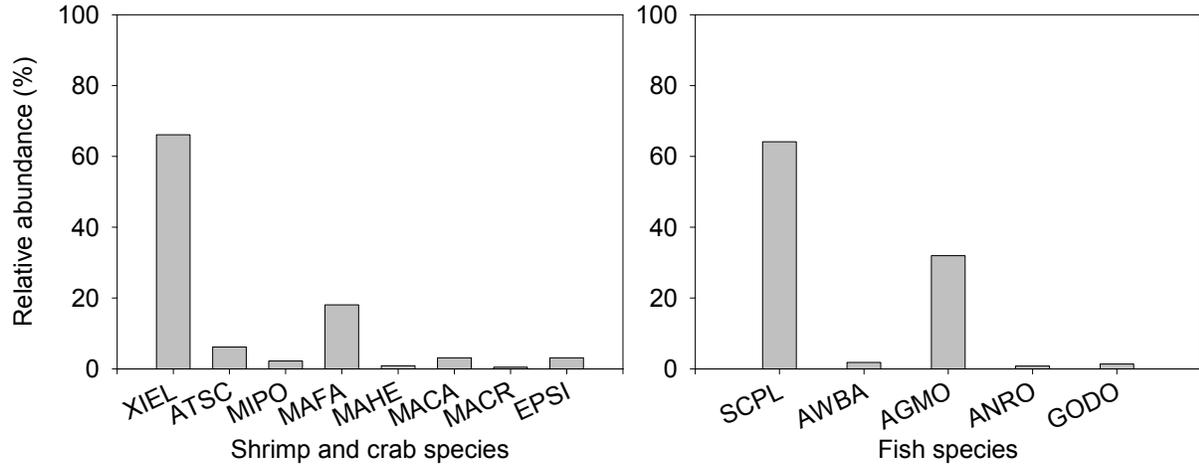


Figure 7. Relative abundance of shrimp and crab and fish species counted by divers in Rio Mameyes, April 2005. Shrimp: XIEL = *Xiphocaris elongata*, ATSC = *Atya scabra*, MIPO = *Micratya poeyi*, MAFA = *Macrobrachium faustinum*, MAHE = *Macrobrachium heterchirus*, MACA = *Macrobrachium carcinus*, and MACR = *Macrobrachium crenulatum*); crab species: EPSI = *Epilobocera sinuatifrons*; fish species: SCPL = *Sicydium plumieri*, AWBA = *Awaous banana*, AGMO = *Agonostomus monticola*, ANRO = *Anguilla rostrata*, and GODO = *Gobiomorus dormitor*.

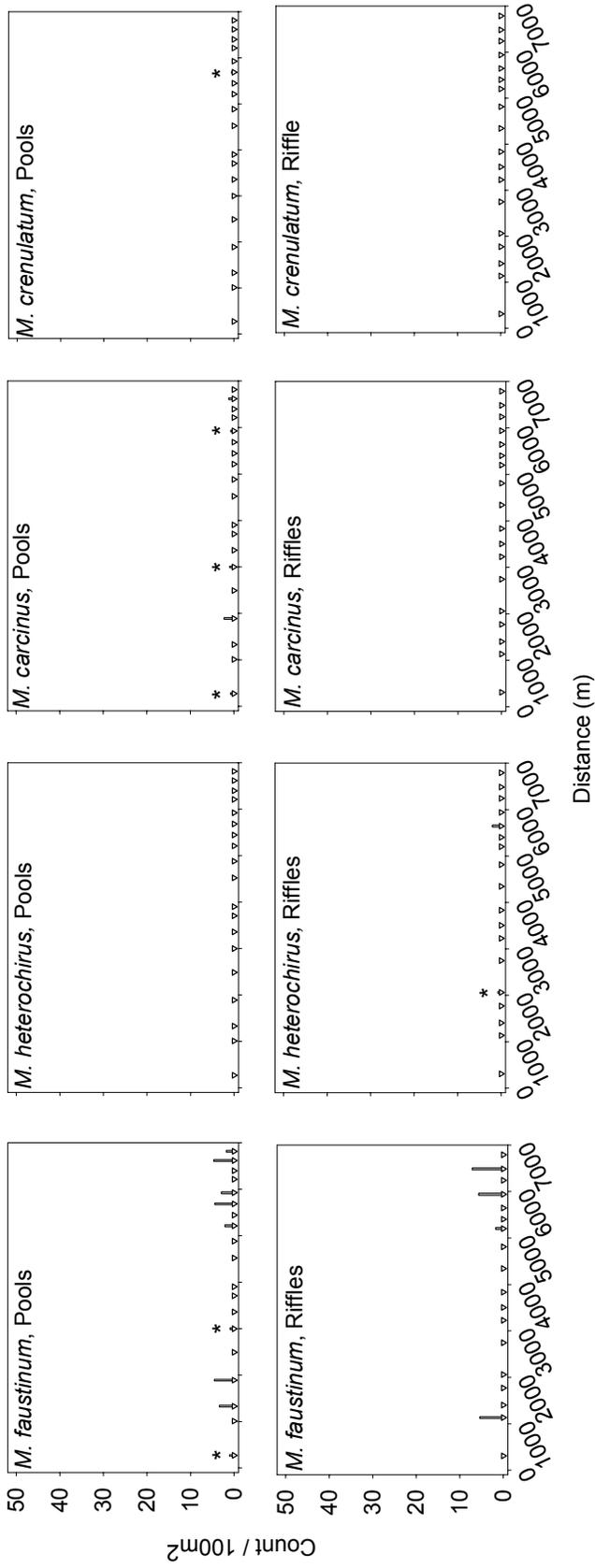


Figure 8. Diver counts of *M. faustinum*, *M. heterochirus*, *M. carcinus*, and *M. crenulatum* per 100 m² in pools and riffles of Rio Mameyes, April 2005. Open triangles indicate diver count locations. Asterisk indicates species was present at density less than 1.0 per 100 m².

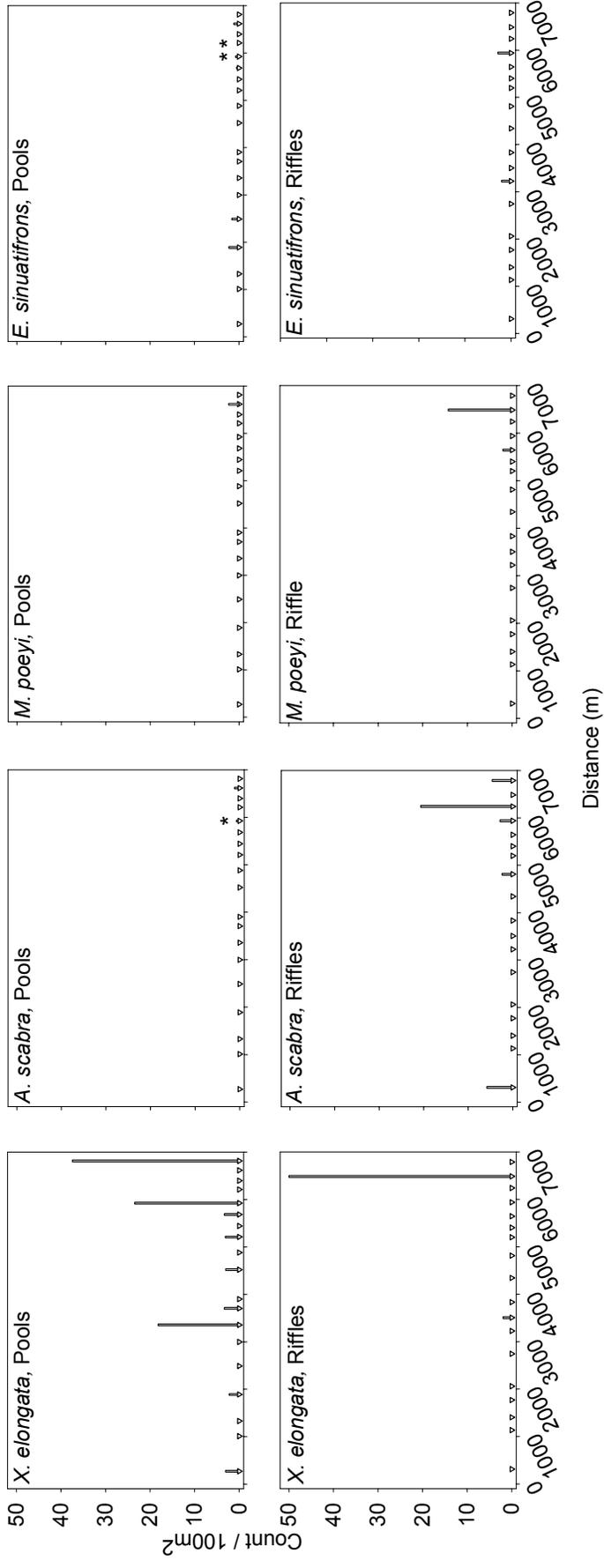


Figure 9. Diver counts of *X. elongata*, *A. scabra*, *M. poeyi*, and *E. sinuatifrons* per 100 m² in pools and riffles of Rio Mameyes, April 2005. Open triangles indicate diver count locations. Asterisk indicates species was present at density less than 1.0 per 100 m².

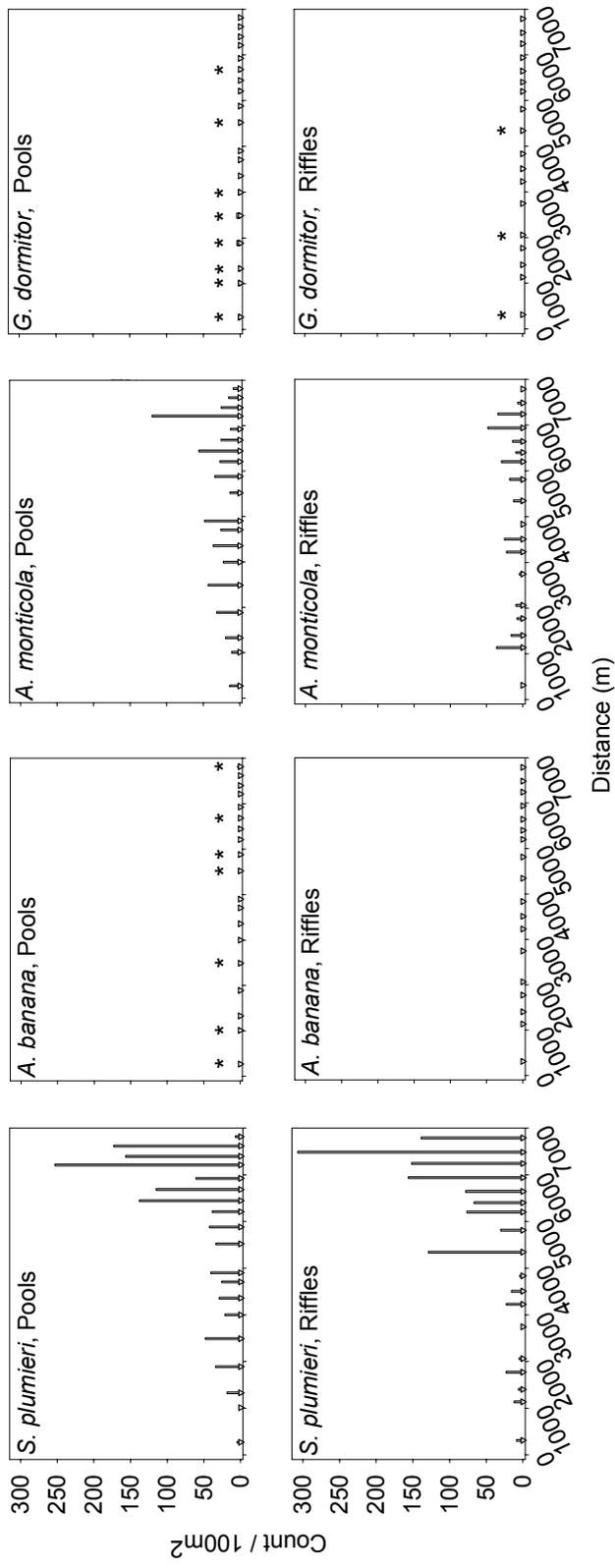


Figure 10. Diver counts of *S. plumieri*, *A. banana*, *A. monticola*, and *G. dormitor* per 100 m² in pools and riffles of Rio Mameyes, April 2005. Open triangles indicate diver count locations. Asterisk indicates species was present at density less than 1.0 per 100 m².

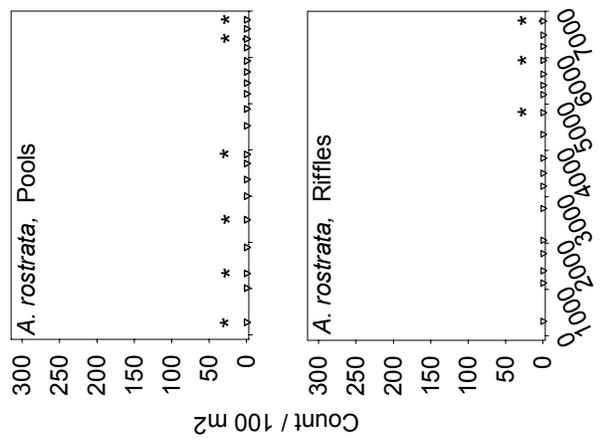


Figure 11. Diver counts of *A. rostrata* per 100 m² in pools and riffles of Rio Mameyes, April 2005. Open triangles indicate diver count locations. Asterisk indicates species was present at density less than 1 per 100 m².