Stomach Content Analysis of the Invasive Mayan Cichlid (*Cichlasoma urophthalmus*) in the Tampa Bay Watershed

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Abstract - Throughout their native range in Mexico, Mayan Cichlids (*Cichlasoma urophthalmus*) have been documented to have a generalist diet consisting of fishes, invertebrates, and mainly plant material. In the Everglades ecosystem, invasive populations of Mayan Cichlids displayed an omnivorous diet dominated by fish and snails. Little is known about the ecology of invasive Mayan Cichlids in the fresh and brackish water habitats in the Tampa Bay watershed. During the summer and fall of 2018 and summer of 2019, adult and juvenile Mayan Cichlids were collected via hook-and-line with artificial lures or with cast nets in seven sites across the Tampa Bay watershed. Fish were fixed in 10% formalin, dissected, and stomach contents were sorted and preserved in 70% ethanol. After sorting, stomach contents were identified to the lowest taxonomic level possible and an Index of Relative Importance (*IRI*) was calculated for each taxon. The highest IRI values calculated for stomach contents of Mayan Cichlids collected in the Tampa Bay watershed were associated with gastropod mollusks in adults and ctenoid scales in juveniles. The data suggest that Mayan Cichlids in Tampa Bay were generalist carnivores.

Introduction

The Mayan Cichlid (*Cichlasoma urophthalmus*) was first described by Günther (1862) as a part of his *Catalog of the Fishes in the British Museum*. They are a tropical freshwater fish native to the Atlantic coast of Central America and can be found in habitats such as river drainages, lagoonal systems, and offshore cays (Paperno et al. 2008). They have also been observed in brackish and marine systems (Stauffer and Boltz 1994). The cichlids have been recorded surviving in a wide range of environmental conditions which has helped them colonize a variety of habitats, where they can out-compete native species (Adams and Wolfe 2007, Bergmann and Motta 2005, Schofield et al. 2009).

Mayan Cichlids have a widely varying diet depending on the habitat they live in making it difficult to determine specific feeding patterns (Chavez-Lopez et al. 2005, Harrison et al. 2013). Vaslet et al. (2012) addressed this problem by focusing their study on a native population of juveniles found in mangrove ponds of Belize. Their research found that the juvenile Mayan Cichlid's diet varied depending on the food available to it. The juveniles in the two ponds sampled fed on similar prey types but in different concentrations (Vaslet et al 2012). Most commonly, the cichlids were recorded eating small crustaceans.

Studies done on Mayan Cichlids in other regions of their native range, like the Terminos Lagoon in Mexico, showed that they were primarily herbivorous, with their diets consisting of 74.41% and 98.3% plant matter in the dry and wet seasons, respectively, but supplemented their diet will small invertebrates such as mollusks and crustaceans (Chavez-Lopez et al. 2005). However, in the Celestún Lagoon in Mexico, cichlids were found to be primarily carnivorous feeding mainly on smaller invertebrates and very little algae (Martinez-Palacios and Ross 1988). Therefore, it is difficult to identify a generalized feeding behavior in this species due to the large variation in its diet across locations.

With the ability to survive and successfully reproduce in a wide range of salinities and low temperatures, *C. urophthalmus* has spread further north in Florida than most tropical fishes. The species was first recorded in the U.S. in the Everglades of southern Florida in 1983 (Loftus 1987) and can now be found consistently in the Everglades and Tampa Bay (Lawson et al. 2017). They are not the only member of family Cichlidae seen in Florida, which now contains 13 known Cichlid species of this nonindigenous lineage (Bergmann & Motta 2005). Their vector of introduction is still unknown. There are several plausible introduction vectors like released aquarium species as Mayan Cichlids were growing in popularity among aquarists in the late 90's and 2000's (Martinez-Palacios et al. 1993), or that Florida is home to several large aquaculture farms and it is possible that these farms were flooded with storm water during past hurricanes which facilitated cichlid introduction. Current United States Geological Survey (USGS) records suggest that the Tampa Bay population is separate from the Everglades population (USGS). However, the Tampa Bay cichlids can be seen expanding south and the Everglades cichlids expanding north. The most up to date USGS records show Mayan Cichlids in high numbers at the Caloosahatchee River tributary in Cape Coral and 30 miles north in the Peace River tributary in Port Charlotte. Continued range expansion at this rate will quickly lead to Mayan Cichlids becoming a very common invasive fish in the waterways of Western Florida.

In contrast to the central American habitats, research done on the invasive populations of southern Florida has revealed different behaviors. Mayan Cichlids were found to be top predators in the Everglades habitats examined, and their occurrence was determined by the amount of prey present at each location (Harrison et al. 2013). In its introduced range of southern Florida, Bergmann and Motta (2005) studied the cichlid's diet throughout its growth from juvenile to adult. They found that adults mostly fed on fish, but they were also recorded feeding on algae, decapods, and snails (Bergmann and Motta 2005). In juveniles, however, the feeding pattern was slightly different. They still fed the most on fish, but were also recorded feeding largely on ostracods, algae, and then detritus. Bergmann and Motta (2005) concluded that Mayan Cichlids remain generalist feeders with a diet dominated by fish and snails, contributing to their success as an invasive species, and that their prey changes as they mature.

In the Tampa Bay region, Mayan Cichlids were first established in two areas: Old Tampa Bay and the lower Hillsborough River (Lawson et al. 2017). Multiple age classes have been observed over these areas, suggesting that Mayan Cichlids were reproducing and becoming more established (Paperno et al. 2008). Our sampling overlapped with the original introduction sites, but the majority cichlids were caught out of the Little Manatee River in southern Tampa Bay, 25 miles away. Lawson et al. (2017) collected few Mayan Cichlids here, and the USGS has no reports of them being found in this river. It can be predicted that Mayan Cichlids, due to their euryhaline tolerance, have been able to spread along the Tampa Bay coast to colonize the lower portion of the bay.

Most of the literature surrounding this cichlid in Florida is based on case studies in the Everglades. As Mayan Cichlid populations expand south from Tampa Bay and north from the Everglades, a clear understanding of the ecology of what will likely become a very common invasive fish, particularly in the northern most portion of their distribution, will be necessary. More work is needed to fully determine the extent of their northern invasion and the possibility of further expansion in and around the Tampa Bay area. Moreover, the research on their relationships with other organisms in Tampa Bay is largely incomplete and could also assist in better understanding and managing their spread. Therefore, this project aims to elucidate Mayan Cichlid feeding behavior in the newly invaded Tampa Bay watershed. Two main hypotheses were addressed. (1) Mayan Cichlids are a generalist omnivore species in Tampa Bay. The invasive populations in the Everglades have been observed as generalist omnivores feeding primarily on fish and snails (Bergmann and Motta 2005) while populations in its native Mexico have been observed as carnivores and herbivores, depending on the system examined (Chavez-Lopez et al. 2005). It is predicted that the invasive population in Tampa Bay will be most similar to the Everglades population and feed on a variety of preys such as shrimps, snails, fishes, and algae. (2) Stomach contents will vary between juveniles and adults. Many fish species shift their diet as they mature (St. John 1999; Ward-Campbell and Beamis 2005). However, it is also possible that their diets will remain the same as they mature. Due to their possible omniovry, one prediction is that Mayan Cichlids diets will have a major shift between juveniles and adults (e.g. juveniles will be primarily herbivorous and adults will be carnivorous). Another prediction is that there will be a minor shift in diets between juvenile and adults where the overall behavior (i.e. carnivory, omnivory, or herbivory) will remain the same, but the specificity of prey will differ.

Methods

Field Methods

Specimens were collected in the summer and fall of 2018 and in the summer of 2019. A total of 77 juvenile and adult Mayan Cichlids were collected by using a combination of cast nets and hook-and-line fishing with artificial lures. The cichlids were collected at seven different sites around Tampa Bay: Sulfur Springs (two adults), Lowry Park (seven juveniles), Bay Crest/Woods Creek (three juveniles, one adult), Plant Park creek (four juveniles, three adults), Alafia River (one juvenile, four adults), Little Manatee River (21 juveniles, 25 adults), and adjacent to Ruskin Inlet in a tidal pond (here after referred to as Ruskin Tidal Pond; six juveniles) (Figure 1).

Laboratory Methods

All specimens were euthanized in MS-222 and fixed in 10% formalin until they were ready to be dissected. They were then rinsed with freshwater and measured for total and standard lengths and mass. Stomachs and intestines were dissected out by cutting from the anal opening to the base of the gills on the ventral side of the cichlid. The stomachs and intestines were separated, and only stomach contents were used in the analysis. Stomach contents were sorted using a dissecting microscope and preserved in 70% ethanol. Food items that were unidentifiable biological material were classified as detritus. Shell fragments without either the opercular opening or spire were classified as shell hash. Contents were identified to the lowest taxon possible and counted, then dried for 60 seconds using a Buchner funnel and weighed.

Data Analysis

To address hypothesis one that stated Mayan Cichlids in Tampa Bay will be generalist omnivores, an Index of Relative Importance (*IRI*) (Hyslop 1980) was used to determine which taxa were most important to the cichlids' diets. The formula is as follows:

$$IRI = (\%N + \%M) * (\%F)$$

where *%N* represents the percentage of the number (i.e. count) of a single prey item from all stomachs divided by the total number of ever prey item collected in every stomach combined, *%M* represents the percentage of mass of a single prey item from all stomachs divided by the total mass of every prey item collected in every stomach combined, and *%F* represents percentage (i.e. frequency) of stomachs the prey item was found in divided by all stomachs. This index was chosen because it attempts to summarize the importance of individual prey taxa that might be missed when analyzing each individual metric and rather, considers all three (i.e. number, mass, or frequency). This eliminates any bias towards one food item or another. For example, *%N* favors smaller food items because a single stomach is more likely to contain a high number of small items compared to larger items, *%M* favors larger food items because a larger item will have a higher mass than a smaller item, and *%F* does not accurately represent the value of high quality, rare food items that could be in the diet. Moreover, this index (Vaslet et al. 2012) and another similar index (Bergmann and Motta 2005) have been used by previous researchers with Mayan Cichlids, thus our work would be comparable to theirs if we used *IRI* too. Finally, a *%IRI* was calculated based on the sum of all *IRI* values to provide a clearer representation for each taxon.

To address hypothesis two that stated there will be a difference in stomach contents between juvenile and adult Mayan Cichlids, a diet-overlap index (Dukowska et al. 2019) was calculated comparing the adult and juvenile stages to determine if there was a significant overlap between the two. The calculation was based on the following equation:

$$C_{xy} = 1 - 0.5 * \left(\sum_i \left| P_{xi} - P_{yi} \right| \right)$$

where P_{xi} is the proportion of food item *i* in the stomachs of group *x* and P_{yi} is the proportion of food item *i* in the stomachs of group *y*. C_{xy} represents the amount of dietary overlap and is measured on a scale of 0 (no overlap) to 1 (complete overlap). Any $C_{xy} > 0.6$ indicates a biologically significant overlap (Dukowska et al. 2019).

Results

Across the seven sites sampled, 77 Mayan Cichlids were caught. By site, two adults were caught at Sulfur Springs, seven juveniles at Lowry Park, three juveniles and one adult at Bay Crest/Woods Creek, four juveniles and three adults at Plant Park, one juvenile and four adults at Alafia River, six adults at the Ruskin tidal pond, and 21 juveniles and 25 adults at the Little Manatee River locations. In total, 36 juveniles and 41 adults were examined.

According to the data, hypothesis one, which stated that Mayan Cichlids would be a generalist omnivore species in Tampa Bay, can be rejected. Mayan Cichlids in the Tampa Bay watershed were primarily carnivorous. The individual metrices (i.e. *%N, %M,* and *%F*) varied substantially for each prey taxon (Figure 3). For example, the snail *M. tuberculata* had the highest *%N* of any taxa with 67.89%. However, it was second in *%M* to detritus/shell hash (30.07%) and third in *%F* behind detritus/shell hash (49.35%) and hydrobiid snails (37.66%) (Figure 3).

When the metrices were indexed into the *IRI*, the stomach contents were found to be 99.05% animal material. The five most common food types were *Melanoides tuberculata* (51.73%), detritus/shell hash (24.49%), snails from the family Hydrobiidae (11.51%), teleost fish (5.19%), and ctenoid scales (4.98%) based on the *%IRI* calculation (Figure 2). Combined, the top five prey taxa had a *%IRI* of 97.90% of the cichlid's diet. There were 21 other taxa found throughout the 77 stomachs (*%IRI* of 2.10% together), yielding 26 total taxa identified (Table 1).

The second hypothesis, which stated that there would be a difference in diet between juvenile and adult Mayan Cichlids was supported and therefore, we fail to reject it. The data suggest that there is a minor ontogenetic shift in the Mayan Cichlid's diet, supporting the second prediction which stated there would be a minor diet shift between juveniles and adults. Both juvenile and adult stages were generalist carnivores with *%IRI* values of 93.16% and 99.80% animal matter, respectively. However, the primary taxa making up their diets were slightly different, and there was no significant diet overlap between the two life stages ($C_{xy} = 0.26$).

In juvenile stomachs, there was a total of 17 taxa identified (Table 2). The five most common were ctenoid scales (48.10%), detritus/shell hash (18.66%), hydrobiid snails (17.45%), chlorophyte algae (7.01%), and hymenopteran insects (4.76%) based on the %IRI calculation (Figure 4). In total, these five taxa yielded a *%IRI* value of 95.98% of the juvenile cichlid's diet. The remaining 12 taxa had a *%IRI* of 4.02%. The individual metrics for each taxon varied in their importance to the diet. For example, the ctenoid scale had the largest *IRI*, however only the *%N* displayed the largest value. The *%M* and *%F* were second and third respectively (Figure 5).

In adult stomachs, there was a total of 18 taxa identified (Table 3). The five most common were *M. tuberculata* (62.98%), detritus/shell hash (22.84%), Teleostei fish (7.56%), Hydrobiidae snails (4.91%), and ctenoid scales (0.61%) based on %IRI calculations (Figure 6). The top five taxa accounted for 98.9% of the diet, with the remaining 13 responsible for 1.1% (Table 3). The individual metrics varied less than the juvenile stomachs. For example, *M. tuberculata* had the largest IRI value, and both the *%N* and *%M* were the largest metrics in their categories (Figure 7). The *%F*, however, was second to detritus/shell hash (Figure 7).

Discussion

The diet of Tampa Bay Mayan Cichlids was most similar to the diet of the initial invasion population in the Everglades, supporting our initial prediction. Our data suggested a carnivorous diet in both juvenile and adult stages. This parallels Bergmann and Motta's (2005) findings that show Mayan Cichlids as primarily piscivorous as juvenile and adults in the Everglades.

There was a difference in diets between juvenile and adult Mayan Cichlids as juveniles had a minor shift in their diet as they matured to adults. This supports our second prediction of a minor diet shift and refutes our first prediction of a major diet shift. While both stages remained generalist carnivores, the specificity of prey targeted was different. The differences yield a C_{xy} value of 0.26, suggesting there is no significant overlap between the two diets. Adults were found to be invertebrate grazers feeding mostly on *M. tuberculata* snails. They also fed on teleostean fish such as the Crested Goby (*Lophogobius cyprinoides*), juvenile Striped Mullet (*Mugil cephalus*), juvenile Common Snook (*Centropomus undecimalis*), juvenile Blackchin Tilapia (*Sarotherodon melanotheron*), and other unidentifiable fish. The common taxa in adult stomachs suggests opportunistic foraging that primarily occurs in the benthos, as indicated by the high importance of *M. tuberculata*.

Juvenile stomachs revealed a different pattern. The most important food item, as indicated by the *IRI*, was ctenoid scales. Lepidophagy, or scale eating, is a type of foraging behavior seen in fish species across the globe, but it has not been recorded in new world cichlids. The behavior can be observed in two forms: active lepidophagy where a fish will attack a larger fish to dislodge scales, and scavenging lepidophagy where a fish will feed on scales of dead fish or scales in the benthos (Baldo et al. 2015). Active lepidophagy has been well studied in an African group of cichlids found in Lake Tanganyika that will attack live fish to dislodge scales (Baldo et al. 2015). These species belong to the genera *Haplotaxodon, Plecodus,* and *Perissodus*, with one species, *Perissodus microlepis*, having 100% of its diet consist of scales in early stages of development (Lee et al. 2015). Scavenging lepidophagy has not been observed in cichlids, but it has been observed in an offshore Leatherjacket species *Oligoplites saurus* (Gosavi et al. 2018) found in Florida, demonstrating that lepidophagy is seen in Florida. However, it is worth noting that this observation was made in laboratory settings. No recorded observations can be found of either form in Mayan Cichlids. One prediction as to why juvenile Mayan Cichlids are feeding on scales is to supplement for a lack of calcium and that the consumption of scales is simply opportunistic feeding. Fish scales are rich in calcium phosphate that can be used to facilitate growth (Janovetz 2005).

The diet of Mayan Cichlids can be used to determine foraging behavior based on their prey's ecology. The most common food taxon across all stomachs was *M. tuberculata*, an invasive species of freshwater gastropod that can be found in multiple systems across the globe and was originally described in India (FWGNA). They are most active at night, using it as time to forage for food. During the day, they bury themselves in the benthos (FWGNA). Additionally, the next most common category of food type was detritus/shell hash. This information supports the idea that Mayan Cichlids are benthic foragers as the high importance of *M. tuberculata* and presence of detritus can be explained by foraging in the benthos. This idea is further supported when examining the species of fish seen in cichlid stomachs. The majority of identifiable fishes (three of six) were gobiids, a benthic oriented family.

These data can also be used to predict the potential impact Mayan Cichlids will have on native fishes. In the Everglades, the density of Mayan Cichlid's increased between winters with a resulting decrease in native species such as Rainwater Killifish and Sheepshead Minnow, which later recovered when colder fronts moved in depleting Mayan cichlid populations (Harrison et al 2013). Tampa Bay serves as a vital estuary and nursery for common fish species, such as the Common Snook and the Red Drum (*Sciaenops ocellatus*) to name a few (Ley et al. 2009), and also as a highly recreationally fished estuary with the Spotted Sea Trout (*Cynoscion Nebulosus*) being the most valued fishery (Fulford et al. 2016). All three of these species, plus the Black Drum (*Pogonias cromis*) and Crested Goby have the potential to be negatively impacted by the Mayan Cichlid's invasion.

Peters and McMichael (1987) determined that juvenile Red Drum in Tampa Bay feed primarily on mysid shrimp, crabs, a variety of fish species. Mysids and crab did not play a large roll in cichlid diets (0% and 0.05% *IRI*'s respectively) and are not likely to be a cause for concern. However, fishes were a top five food item in adult cichlid stomachs (7.56% *IRI*). As Mayan Cichlids become more established, this *IRI* value could continue to grow as well. McMichael and Peters (1989) also reported that juvenile Spotted Sea Trout in Tampa Bay feed heavily on fishes (including gobiids) and shrimp (*Palaemonetes* and *Hippolyte*). Gobiids were the most common fish in adult cichlid stomachs, indicating a high potential for competition as cichlid numbers rise. *Palaemonetes* shrimp were found in juvenile stomachs, but at a small proportion (0.23% *IRI*). Juvenile Black Drum in Tampa Bay were recorded feeding primarily on mollusks and fish scales were common across the development as well, although they were not explicitly measured (Peters and McMichael 1990). There is perhaps the largest chance for negative competition here as the number one food source in Mayan Cichlids was scales as juveniles and mollusks as adults (48.10% and 62.98% *IRI*, respectively). As predators, Mayan Cichlids were recorded feeding on Snook and Crested Gobies, giving the potential to cause damage to the Snook fishery.

While this study did demonstrate a shift in diets between juvenile and adult Mayan Cichlid, it should be noted that our sampling methods covered several different areas in three river systems. There were locations where juvenile cichlids were caught and no adults, and areas where adults were caught and no juveniles. More data on individual habitats is needed to fully determine the extent of this diet shift. Future studies should include increased collections at a single habitat to provide enough samples to demonstrate the diet shift is due to ontogeny and not a difference in prey availability or habitat. Additionally, the method of lepidophagy in Mayan's is still uncertain. To fully determine where the scales were coming from, observational studies would need to be done to see if juvenile cichlids were attacking other fish, or benthic pulls would need to be done in the locations sampled to see if the scales were in high concentrations in the benthos. Further site exploration would have to be done as well to determine if there were anthropogenic reasons (*i.e.* fish cleaning stations) causing accumulations of scales in certain locations.

Mayan Cichlids have become an established invasive in Tampa Bay and appear to be expanding their range further south. Continued southward movements could present conservation concerns for native fish species in Florida due to increasing competition, predation, and interactions with the cichlids. A clear understanding of Mayan Cichlid ecology and distributions is vital to management efforts in protecting native Florida fish species and predicting future implications of this invasion.

Acknowledgements

I would like to acknowledge Kassandra Weeks for her help in dissecting, sorting, and identifying stomach contents, Luke Bishop for his help collecting and providing images for the project, Doctors Kevin Beach and Abraham Miller for all their help in the revision process, and The University of Tampa's Office of Undergraduate Research and Inquiry, College of Natural and Health Sciences, and Honor's Program for travel and funding throughout the duration of the project. I would also like to greatly thank Mr. Louis Ambrosio for all his efforts collecting cichlids and identifying prey taxa, and Dr. Mark McRae for advising me through this project and helping me grow into a better, more thorough, and more successful researcher.

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Tables and Figures

Table 1: Identified taxa, % Number (*%N*), % Mass (*%M*), % Frequency (*%F*), IRI, and *%IRI* for every food item collected in juvenile and adult Mayan Cichlid stomachs. Table is sorted according to Ranking column from largest *%IRI* to smallest.

Ranking	%N	%M	%F	IRI	%IRI
Melanoides tuberculata	67.89	28.67	32.47	3135.07	51.73
Detritus/Shell Hash	0.00	30.07	49.35	1484.09	24.49
Family Hydrobiidae	17.12	1.40	37.66	697.65	11.51
Division Teleostii	0.66	23.58	12.99	314.75	5.19
Ctenoid Scale	8.12	1.98	29.87	301.70	4.98
Phylum Chlorophyta	0.00	2.12	27.27	57.83	0.95
Palaemonetes sp.	0.71	2.06	7.79	21.61	0.36
Order Hymenoptera	2.47	0.03	6.49	16.26	0.27
Aratus pisonii	0.16	4.16	2.60	11.22	0.19
F. Gammaridae	0.99	0.25	6.49	8.05	0.13
Family Chironomidae	0.60	0.22	2.60	2.15	0.04
S.P. Vertebrata	0.11	1.42	1.30	1.98	0.03
Uca sp.	0.05	1.05	1.30	1.43	0.02
Family Libellulidae	0.11	0.44	2.60	1.42	0.02
Eurypanopeus depressus	0.05	0.98	1.30	1.35	0.02
C. Ostracoda	0.27	0.00	3.90	1.07	0.02
F. Geometridae	0.05	0.59	1.30	0.84	0.01
Family Formicidae	0.11	0.12	2.60	0.60	0.01
Parasterope pallex	0.22	0.13	1.30	0.45	0.01
Amphibalanus sp.	0.05	0.22	1.30	0.36	0.01
F. Xanthidae	0.05	0.18	1.30	0.31	0.01
Family Dytiscidae	0.05	0.11	1.30	0.21	0.00
Nematode	0.05	0.10	1.30	0.20	0.00
Order Isopoda	0.05	0.07	1.30	0.16	0.00
P. Rhodophyta	0.00	0.04	2.60	0.11	0.00
Cyanobaceria	0.00	0.01	1.30	0.01	0.00

Table 2: Identified taxa, % Number (*%N*), % Mass (*%M*), % Frequency (*%F*), IRI, and *%IRI* for every food item collected in juvenile Mayan Cichlid stomachs. Table is sorted according to Ranking column from largest *%IRI* to smallest.

Ranking	%N	%M	%F	IRI	%IRI
Ctenoid Scales	53.36	12.14	41.67	2729.13	48.10
Detritus/Shell Hash	0.00	29.33	36.11	1059.01	18.66
F. Hydrobiidae	15.55	2.28	55.56	990.28	17.45
P. Chlorophyta	0.00	8.42	47.22	397.52	7.01
O. Hymenoptera	18.91	0.54	13.89	270.06	4.76
Melanoides tuberculata	4.20	1.12	13.89	73.96	1.30
S.P. Vertebrata	0.84	22.20	2.78	64.01	1.13
F. Geometridae	0.42	9.31	2.78	27.04	0.48
C. Ostracoda	2.10	0.00	8.33	17.51	0.31
Palaemonetes sp.	0.42	4.35	2.78	13.26	0.23
Parasterope pallex	1.68	2.04	2.78	10.32	0.18
F. Xanthidae	0.42	2.89	2.78	9.19	0.16
F. Libellulidae	0.42	2.56	2.78	8.28	0.15
F. Chironimidae	0.84	1.63	2.78	6.87	0.12
F. Gammaridae	0.84	0.42	5.56	7.00	0.12
P. Rhodophyta	0.00	0.68	5.56	3.78	0.07
Cyanobacteria	0.00	0.09	2.78	0.24	0.00

Table 3: Identified taxa, % Number (*%N*), % Mass (*%M*), % Frequency (*%F*), IRI, and *%IRI* for every food item collected in adult Mayan Cichlid stomachs. Table is sorted according to Ranking column from largest *%IRI* to smallest.

Ranking	%N	%M	%F	IRI	% IRI
Melanoides tuberculata	77.46	30.54	48.78	5268.64	62.98
Detritus/Shell Hash	0.00	30.12	63.41	1910.25	22.84
Division Teleostii	0.76	25.18	24.39	632.71	7.56
F. Hydrobiidae	17.36	1.34	21.95	410.51	4.91
Ctenoid Scale	1.33	1.28	19.51	50.94	0.61
Palaemonetes sp.	0.76	1.90	12.20	32.44	0.39
Aratus pisonii	0.19	4.44	4.88	22.58	0.27
P. Chlorophyta	0.00	1.69	9.76	16.50	0.20
F. Gammaridae	1.01	0.24	7.32	9.15	0.11
Eurypanopeus depressus	0.06	1.05	2.44	2.71	0.03
Uca sp.	0.06	1.12	2.44	2.88	0.03
F. Chironomidae	0.57	0.13	2.44	1.70	0.02
F. Formicidae	0.13	0.13	4.88	1.25	0.01
F. Dytiscidae	0.06	0.11	2.44	0.43	0.01
Amphibalanus sp.	0.06	0.24	2.44	0.74	0.01
F. Libellulidae	0.06	0.29	2.44	0.87	0.01
O. Isopoda	0.06	0.07	2.44	0.33	0.00
Nematode	0.06	0.11	2.44	0.41	0.00

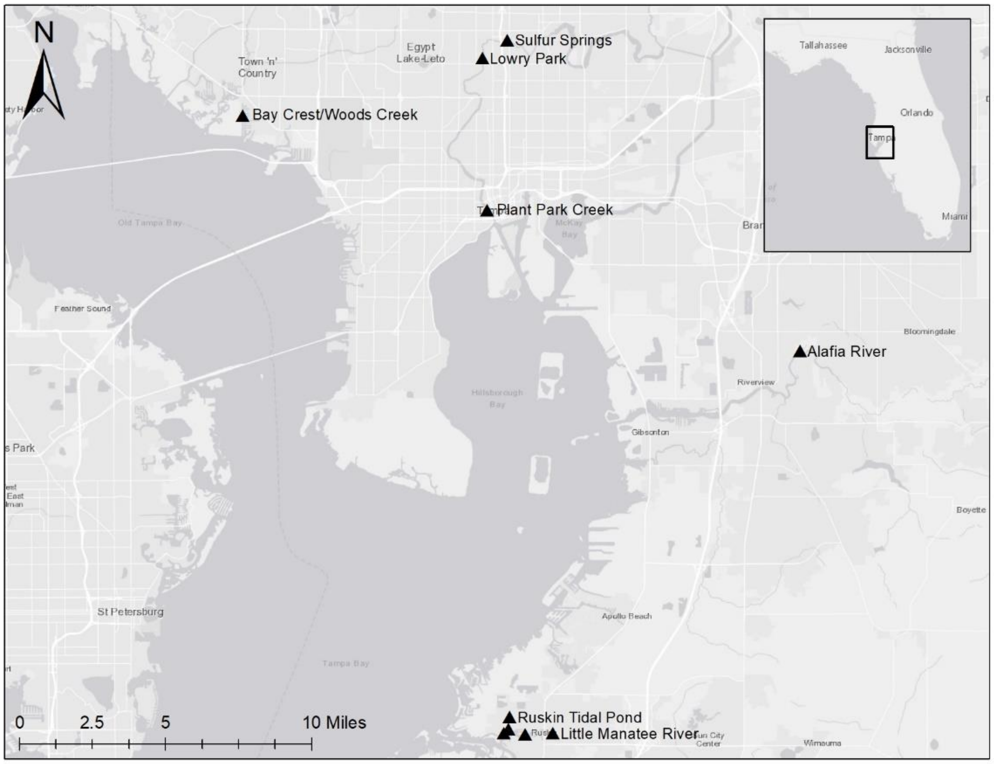

Figure 1: Seven sites sampled for Mayan Cichlids in the Tampa Bay watershed. The majority of collected cichlids were from the southern most site, the Little Manatee River. There were four separate collecting locations along this river. The remaining sites had one collecting location only.

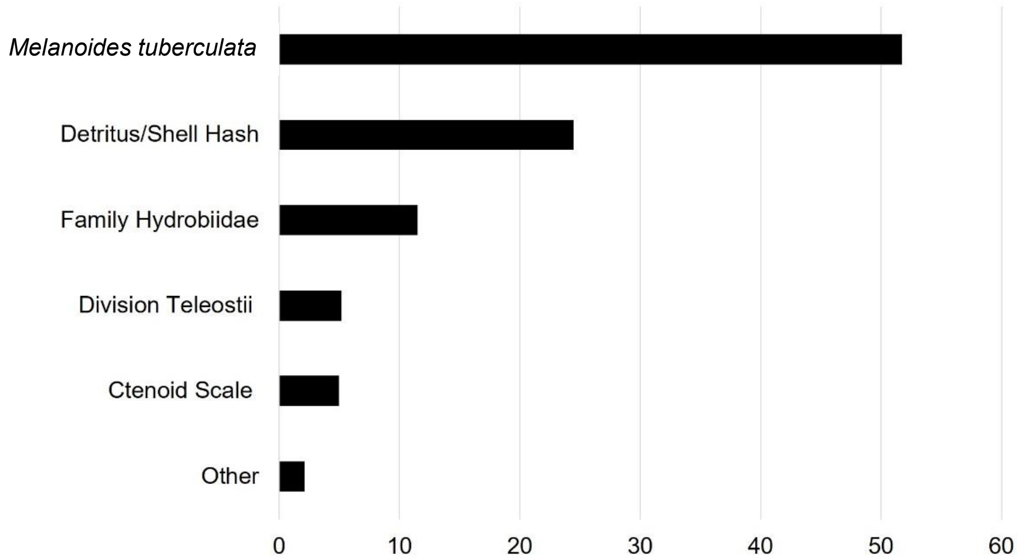

Figure 2: Percent *IRI* values of the top five taxa and "other" found in juvenile and adult Mayan Cichlid stomachs. Percent *IRI* was calculated using the three measured metrices (% Frequency, % Mass, and % Number). "Other" represents the remaining 21 taxa combined into one category for ease of viewing. For complete list of taxa including in "other", see table 1. The freshwater snail, *Melanoides tuberculata* had the highest *%IRI* value, indicating it is the most common prey taxa in Mayan Cichlid diets.

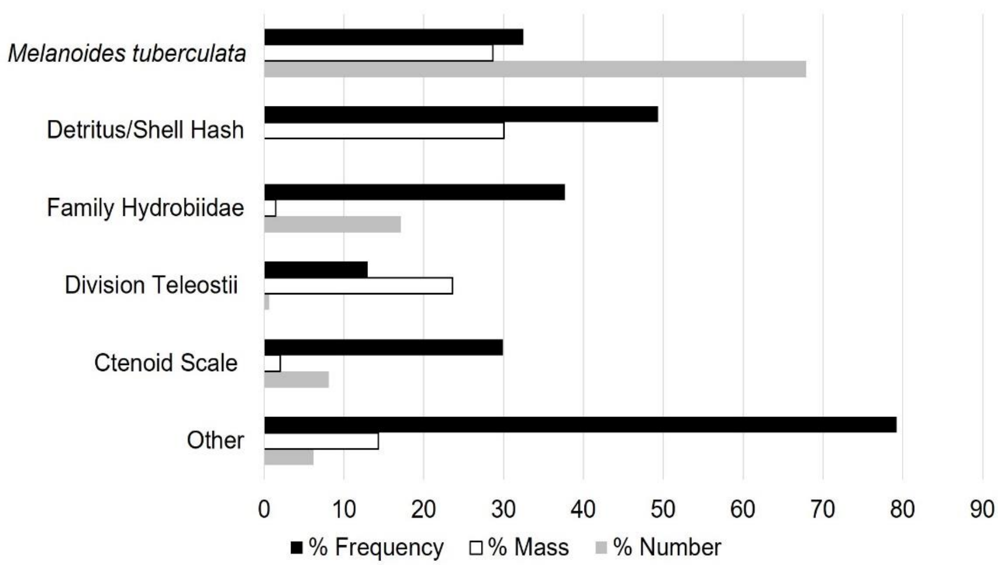

Figure 3: Individual metrices (% Frequency, % Mass, and % Number) for top five taxa and "other" across juvenile and adult Mayan Cichlid stomachs. "Other" represents the remaining 21 taxa combined into one category for ease of viewing. For complete list of taxa in "other", see table 1.

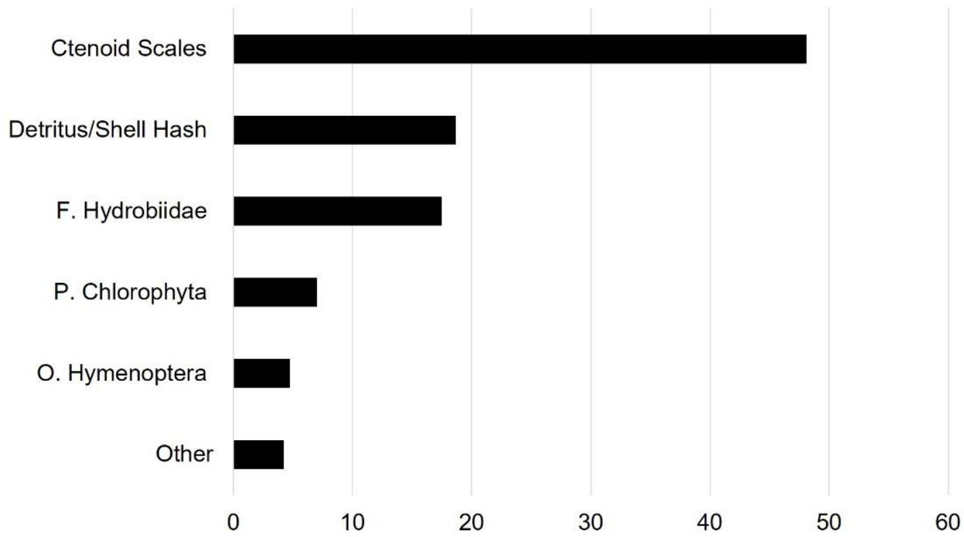

Figure 4: Percent *IRI* values of the top five taxa and “other” found in juvenile Mayan Cichlid stomachs. Percent *IRI* was calculated using the three measured metrices (% Frequency, % Mass, and % Number). “Other” represents the remaining 12 taxa combined into one category for ease of viewing. For complete list of taxa including in “other”, see table 2. Ctenoid scales had the highest *%IRI* value, indicating they are the most common prey taxa in juvenile Mayan Cichlid diets.

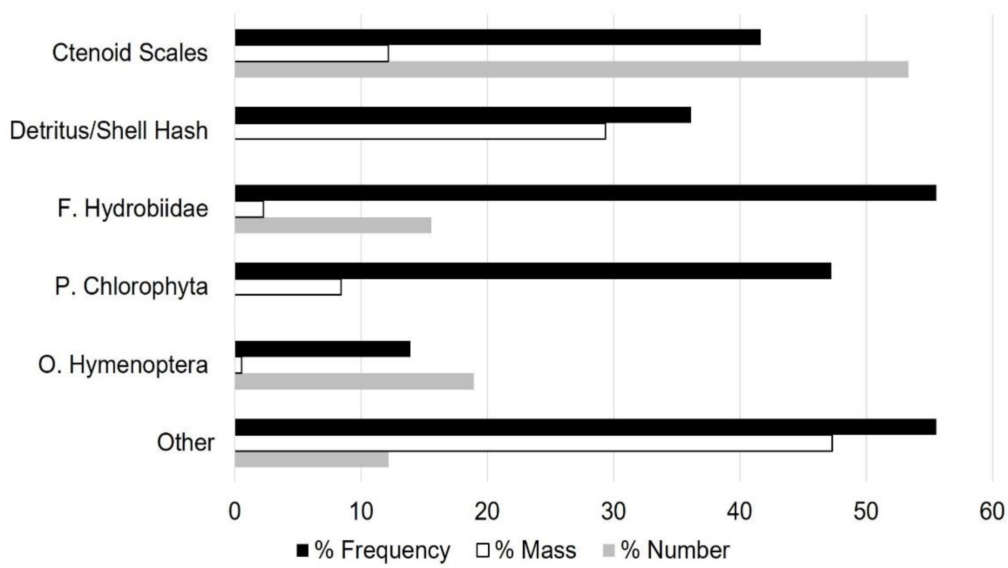

Figure 5: Individual metrices (% Frequency, % Mass, and % Number) for top five taxa and “other” for juvenile Mayan Cichlid stomachs. “Other” represents the remaining 12 taxa combined into one category for ease of viewing. For complete list of taxa including in “other”, see table 2.

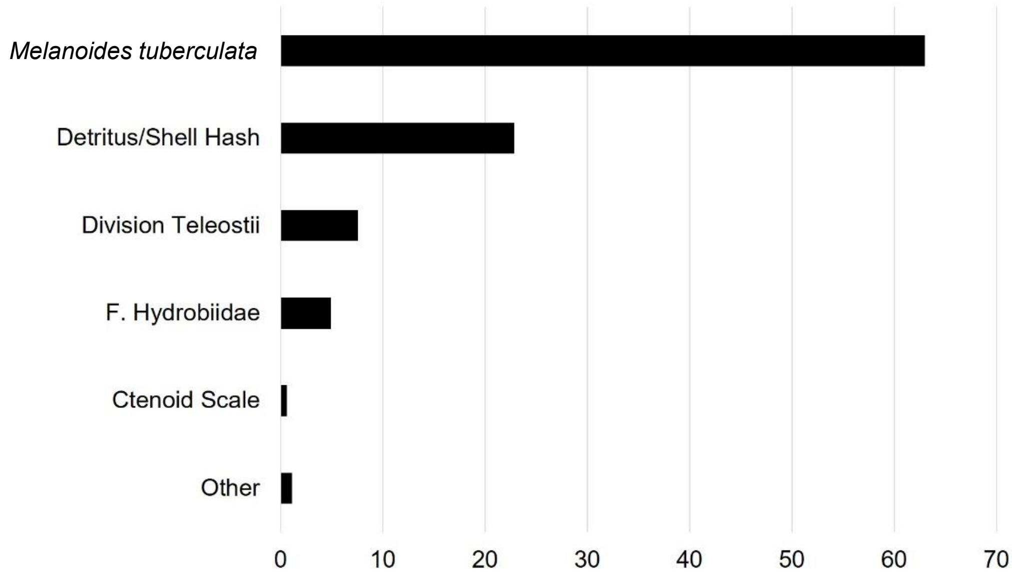

Figure 6: Percent *IRI* values of the top five taxa and "other" found in adult Mayan Cichlid stomachs. Percent *IRI* was calculated using the three measured metrices (% Frequency, % Mass, and % Number). "Other" represents the remaining 13 taxa combined into one category for ease of viewing. For complete list of taxa including in "other", see table 3. The freshwater snail, *Melanoides tuberculata*, had the highest *%IRI* value, indicating it is the most common prey taxa in adult Mayan Cichlid diets.

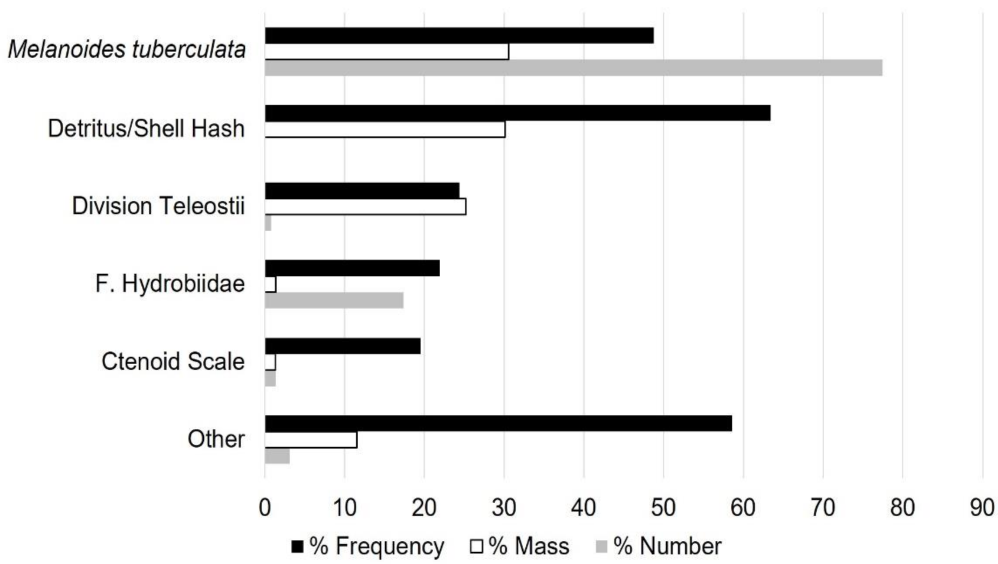

Figure 7: Individual metrices (% Frequency, % Mass, and % Number) for top five taxa and "other" for adult Mayan Cichlid stomachs. "Other" represents the remaining 13 taxa combined into one category for ease of viewing. For complete list of taxa including in "other", see table 3.