The Diet of the freshwater clingfish, *Gobiesox cephalus* (Teleostei: Gobiesocidae)

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Abstract

The purpose of this study is to describe the diet of the freshwater clingfish, *Gobiesox cephalus* (Lacepède 1800), based on specimens collected from the Belfast River in Dominica, West Indies. 29 specimens were collected in total from an 88 foot stretch of river, with an average depth of 8.16 inches and average velocity of 0.7 m/s. Stomach content analysis revealed the diet of the freshwater clingfish to be comprised almost exclusively of aquatic insect larvae, specifically Trichoptera, Chironomidae, Ephemeroptera, Zygoptera, Diptera, and unidentifiable insect parts. Cycloid scales and small stones were also found in the stomachs of a small number of individuals. The diet of the freshwater clingfish differs from that of other clingfishes that have been investigated to date, which feed predominantly on crustaceans and other hard-bodied invertebrates.

Introduction

Members of the family Gobiesocidae are small marine fishes found predominantly in the intertidal zones of the Atlantic (including the Mediterranean Sea) and Indo-Pacific Oceans (Briggs, 1955). There are however a few members of the family that inhabit freshwater. The freshwater species are predominately found in Central and northern South America and inhabit fast moving rivers (Briggs, 1955). Commonly known as clingfish, gobiesocids possess a remarkable suction disk on their ventral surface with which they attach to the substrate (Wainwright et al., 2014). At present, there are 164 species distributed across 47 genera (Eschmeyer and Fong, 2011).

Species of clingfish are poorly studied and relatively little is known about their ecology and biology (Conway and Prestridge, 2011). The results of previous investigations on the diet and feeding behavior of marine clingfishes indicate that they are microcarnivores, feeding on a variety of invertebrates (Johnson, 1970; Stobb, 1970), the eggs and scales of other fishes (Hirayama et al., 2005) or other clingfishes (Pires & Gibran, 2011). The dietary habits of the freshwater clingfish *Gobiesox cephalus* (Figure 1) have yet to be studied. The purpose of this study is to investigate the diet of a West Indian population of the freshwater clingfish inhabiting the Belfast River on the Island of Dominica.

Materials and Methods

Study Site

The Belfast River is located along the East coast of Dominica, meeting the Caribbean Sea at the town of Mahaut. The collecting site (15° 22.14′ N, 61° 24.042′ W), situated approximately 400 meters upstream from the mouth of the river, encompassed an area of 2948 sq. feet and had an

Figure 1. *Gobiesox cephalus* found in the Belfast River.

average depth of 8.16 inches and average water velocity of 0.7 m/s. Specimens were collected over three consecutive days. This included one collection in the evening and two morning collections. Specimens were collected using a dip net during snorkeling. 11 specimens were also observed in situ for a short period of time prior to capture. Once collected, specimens were put into a bucket with a small air bubbler prior to being taken back to the lab. Flow rate and depth of capture were also measured at the position at which specimens were first observed prior to capture. To find the total area of the site the width across the river at two locations and then a measurement of the length between them and area formulas were used to calculate the total area. To find the average depth and water velocity the measuring tape was secured across the width of the river in the same two locations used in the area calculations. Then depth and flowmeter measurements were taken every 40 inches. All the data were averaged together for the total depth and total water velocity. To get the water velocity we used a Geopacks MFP51 Flowmeter. The flowmeter was run for 30 seconds and the number of rotations was recorded. That number must be doubled to equal number of rotations per minute then put into the formula V=0.000854 (# of rotations per minute) + 0.05 to get the water velocity in meters/seconds.

Stomach Content Analysis

Standard length (SL) was measured using a pair of digital calibers. Once measured, specimens were anesthetized using a few drops of clove oil, removed of excess mucous and placed in a dissecting tray. A small clip from the right pectoral fin was also collected and put into a small vial of alcohol to serve as a future source of DNA. Next, the abdominal cavity was opened using a pair of dissecting scissors and forceps. An incision starting at the anus and curving slightly up the right side cutting up to the bottom of the suction disc was made. The alimentary canal could then be lifted and pulled out by cutting away connective tissues and then removed from the body by severing the esophagus and rectum. Once removed from the body, the stomach was cut open and the contents were put into a small container of water, and then examined under a dissecting microscope. Once examined, stomach contents were put into a labeled bottle with alcohol. Specimens were then stored in a solution of 10% formalin.

The stomach content of each individual was identified and split into the following categories: (1) inorganic material; (2) fish scales; and (3) insects. Insects were split further into more specific categories (lowest taxonomic rank possible). The frequency of occurrence (Bowen, 1992) and the percentages composition (Hynes, 1950) of individual items was calculated using Microsoft Excel. We also analyzed stomach content data for individuals above 40mm SL and below 40mm SL separately to assess whether an ontogenetic transition in diet occurs in this species.

Results

A total of 29 specimens of *Gobiesox cephalus*, ranging in size from 16.8 mm to 134.0 mm SL, were collected. Of the 29, only 20 had stomachs with content. Those possessing stomach content ranged in size from 16.8 mm to 70 mm SL, with one specimen not receiving a measurement due to an oversight. Stomach content was predominately composed of various unidentifiable aquatic insect parts and whole aquatic insect larvae (identifiable to the level or order or in some cases family), some inorganic material (pebbles), and fish scales. Appendix 1 lists the raw data for this study.

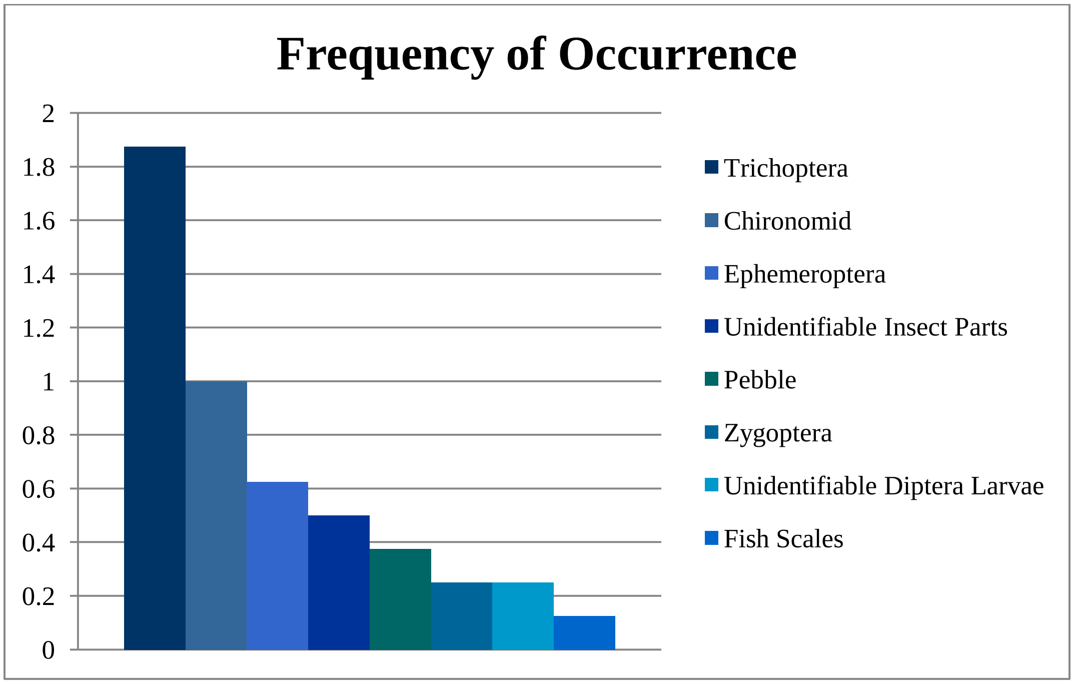

Figure 1. Frequency of Occurrence of food items found in stomach contents of 20 individuals of *Gobiesox cephalus.*

Caddisfly larvae (Trichoptera) were the most abundant identifiable food item by a wide margin, with a Frequency of Occurrence of 1.875. Chironomid larvae (Chironomidae) also occurred fairly frequently, with a Frequency of Occurrence of 1.0, while Mayfly larvae (Ephemeroptera) were the third most encountered item, with a Frequently of Occurrence of 0.625. Various unidentifiable insect parts came next, with a Frequency of Occurrence of 0.5, while small pebbles (most likely inadvertently ingested) had a Frequency of Occurrence of 0.375. Both damselfly larvae (Zygoptera) and unidentifiable dipteran larvae had a Frequency of Occurrence of 0.25. Finally, fish scales had a Frequency of Occurrence of 0.125 (Figure 1).

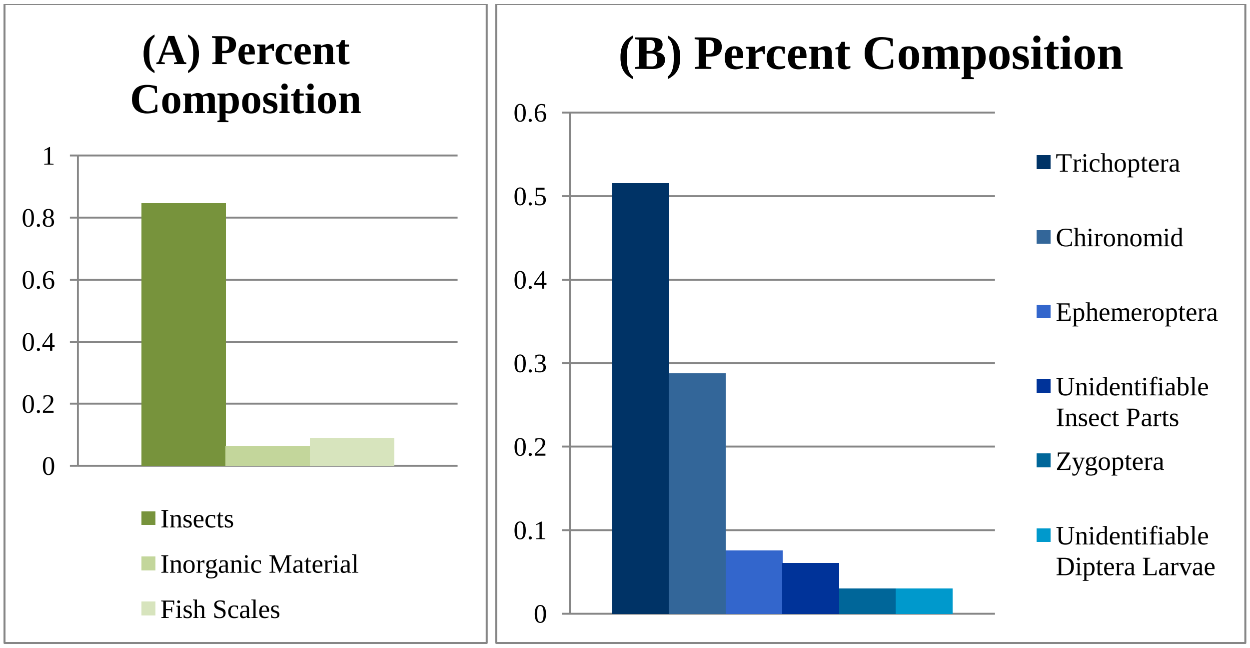

Figure 2. Composition of food items found in stomachs of 20 individuals of *Gobiesox cephalus*: (**a**) broad classifications; (**b**) only insects/insect larvae.

As shown in Figure 2, insect material was the predominant food item found in the stomachs of *Gobiesox cephalus*, while inorganic material (pebbles) and fish scales made up a small portion of the contents. The Percent Composition of insect material was 0.846, while inorganic material was 0.064 and fish scales were 0.089. Of the identifiable insect larvae, caddisfly larvae made up a significant amount of the contents analyzed with a Percent Composition of 0.515. Chironomids followed closely with a Percent Composition of 0.288. Mayfly larvae, unidentifiable insect parts, damselfly larvae, and unidentifiable dipteran larvae each had a Percent Composition of 0.076, 0.061, 0.030, and 0.030, respectively.

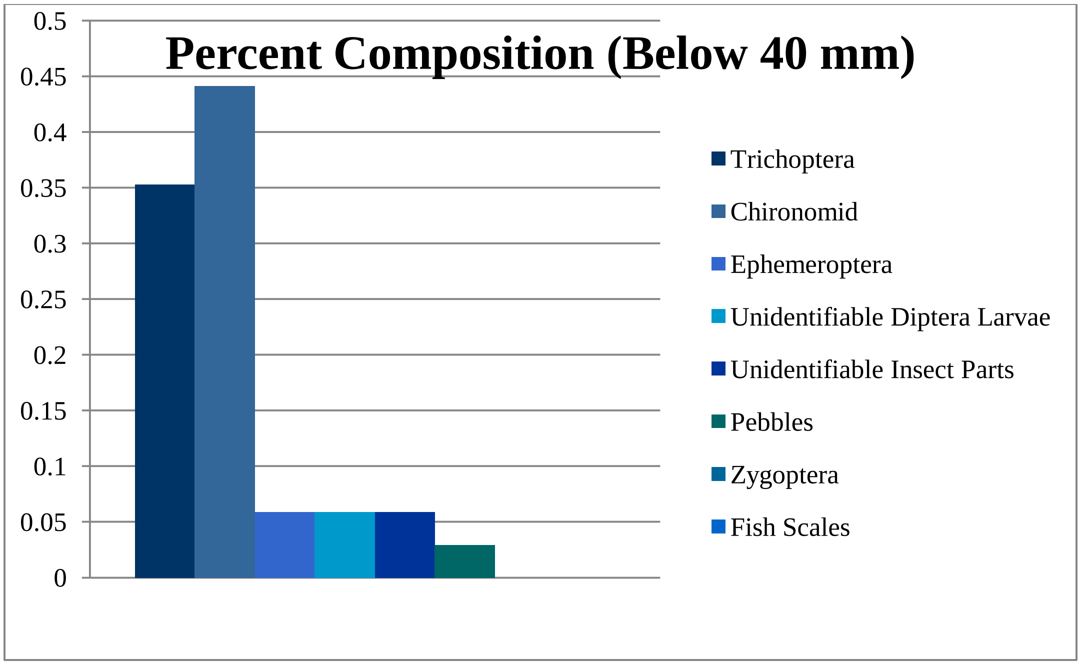

Figure 3. Percent Composition of stomach content of *Gobiesox cephalus* below 40 mm SL.

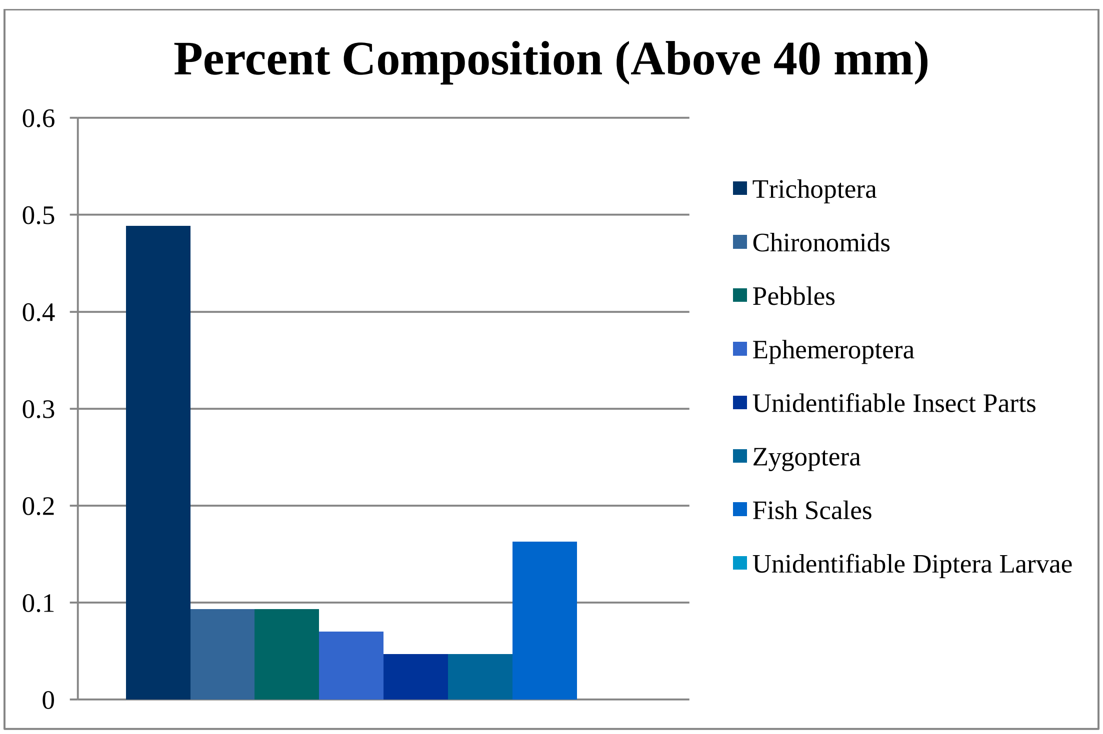

Figure 4. Percent Composition of stomach content of *Gobiesox cephalus* above 40 mm SL.

As some species of clingfishes have been reported to exhibit an ontogenetic transition in diet in relation to body size, the Percent Composition of stomach content of *Gobiesox cephalus* above and below 40 mm SL was analyzed separately (Figures 3 and 4). There appeared to be little discernible difference in diet between the two size ranges, with both caddisfly larvae and chironomid larvae being the food items most consumed.

Discussion

Our investigation has revealed aquatic insect larvae to be the most common item in the diet of the freshwater clingfish, *G. cephalus*. A wide variety of aquatic insects are consumed, including, but not limited to, caddisfly larvae, damselfly larvae and mayfly larvae. This is surprising when compared to the diets of marine congeners, which predominantly feed on hard shelled invertebrates (Johnson, 1970; Pires & Gibran, 2011). Though hard shelled invertebrates (e.g., aquatic mollusks and a variety of small crustaceans) are abundant in the habitat of *G. cephalus* there is as yet no evidence that clingfish actively feeding on them. This suggests that a dietary transition (from hard bodied marine invertebrates to aquatic insect larvae) has accompanied the habitat transition from marine to freshwater in the lineage including *G. cephalus*.

Some species of clingfish have been reported to exhibit an ontogenetic diet transition, where they begin to feed on other prey items as they increase in size (Johnson, 1970). Although our results did not support a shift in diet associated with an increase in body size for *G. cephalus* this could be due to the small number of individuals collected with full stomachs (n=20) and examined as part of our study (Figures 3 & 4). Many of the specimens above 40mm SL that we examined had empty stomachs. Clingfishes exhibit male parent care and are reported to cease feeding during egg guarding (Briggs, 1955). The largest individual that we encountered during our study (134.00 mm SL) was guarding a clutch of eggs and this may explain the lack of stomach content for this particular individual.

Another interesting aspect of our study is the discovery of mucoid fecal capsules containing digested material in the stomach and intestine of *G. cephalus*. Other species of clingfish are reported to produce mucoid fecal capsules (Stobbs, 1980; Pires & Gibran, 2011) suggesting that fecal capsules may be widespread within the family. The composition and function of these mucoid fecal capsules is currently unknown, but it is presumed that they aid in digestion by protecting the intestines from sharp or hard prey parts (Stobbs, 1980). Further investigation of digestion and defecation in clingfishes is warranted.

Acknowledgements

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Appendix 1.

Specimen	Length (mm)	Digestive Contents
A5	///	(1) Caddisfly larvae
A1	134	Nothing
B1	107.75	Nothing
A2	70	(1) Caddisfly larvae, (1) Mayfly larvae thorax, (1) unidentifiable insect part
C2	69.07	(1) Damselfly larvae (odonata)
C1	67.8	(1) pebble
B3	65.56	Nothing
C3	64	(1) Caddisfly larvae
B4	63.91	Nothing
A3	62	(1) unidentifiable insect part, (1) glass shard, (1) seed
B2	58	Nothing
B5	57.55	Nothing
A4	56	(1) Chironomid, (11) Caddisfly larvae
A6	51.5	(1) Caddisfly larvae
C5	50.93	(1) Mayfly larvae
C4	47.77	100% fish scales
C6	45.07	Nothing
B6	40.58	(2) Pebbles, (3) Caddisfly larvae
B7	40.43	(1) Caddisfly larvae, (1) Chironomid, (1) fish scales, (1) Mayfly larvae
A7	40.14	(2) Chironomids, (3) Caddisfly larvae
B8	36.94	(1) Caddisfly larvae, (1) pebble, (1) unidentifiable insect parts
B9	36.53	(2) Caddisfly larvae, (1) Chironomid
C7	32.53	(1) Caddisfly larvae, (1) Mayfly larvae, (7) Chironomids
A8	28.77	Nothing
B10	24.09	Nothing
C9	24	(4) Caddisfly larvae, (1) Chironomid, (1) Diptera
A9	21.58	(1) partially digested insect larvae, (1) Caddisfly larvae, (2) Chironomid
C8	19.01	(4) Chironomids, (1) Diptera, (1) Caddisfly larvae, (1) Mayfly larvae
B11	16.8	(2) Caddisfly larvae