An Investigation of substrate scrapping behavior in three species of sicydiine gobies (genus *Sicydium*) inhabiting freshwater streams on Dominica, West Indies

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Abstract

Gobies of the genus *Sicydium* are freshwater fishes present throughout the western Central Atlantic and eastern Central Pacific. They feed by scraping algae from hard surfaces in fast flowing rivers and streams and have highly modified teeth used for scraping. This study focuses specifically on the frequency of substrate scraping during feeding in three different species of *Sicydium* found on Dominica (*S. buscki, S. plumieri* and *S. punctatum*). A total of 13 video recordings of scraping events were obtained using a waterproof digital camera and analyzed using appropriate software. Twenty-nine individual sicydiine gobies were documented: *S. punctatum* (n=11), *S. plumieri* (n=5), *S. buscki* (n=11). Results show that there are significant differences in the frequency of scraping in the different species of *Sicydium*. The total length range for *S. punctatum* was 22.0–71.2 mm, 32.3–117.0 mm for *S. plumieri*, and 42.4–71.0 mm for *S. buscki*. The head length range for *S. punctatum* was 3.9–13.5 mm, 8.0–25.3 mm for *S. plumieri*, and 9.8–16.2 mm for *S. buscki*. The range of scrapes per second for *S. punctatum* was 9–11, 2–6 for *S. plumieri*, and 3.5–6.5 for *S. buscki*. *Sicydium punctatum* had an average total length of 41.6 mm, an average head length of 7.4 mm, and an average of 9.9 scrapes per second. *Sicydium plumieri* had an average total length of 76.5 mm, an average head length of 17.6 mm, and an average of 3.9 scrapes per second. *Sicydium buscki* had an average total length of 56.4 mm, an average head length of 12.1 mm, and an average of 4.7 scrapes per second. A further question that could not be determined based on these findings was whether *S. punctatum* and *S. buscki* have a decrease in scraping frequency as their size increases.

Introduction

Dominica has relatively few freshwater fishes compared to other Caribbean islands (FishBase, 2016). All of Dominica's freshwater fishes migrate regularly between fresh water and marine water (diadromy), in both directions, at some stage of their life cycle and not only to spawn. This includes the amphidromous gobies of the genus *Sicydium*, which according to FishBase's "List of Freshwater Fishes reported from Dominica" are all native. Gobies of the genus *Sicydium* have the pelvic fins fused across the midline to form a ventral adhesive disc (Maie et al., 2007). This adhesive disc allows gobies to adhere and cling to the substrate of fast flowing rivers and streams and even enables *Sicydium* gobies to climb waterfalls (Maie et al., 2007). *Sicydium* gobies feed by scraping diatoms or algae from hard surfaces in fast flowing rivers and streams and have

highly modified teeth that are adapted for scraping (Patzner et al., 2012). Dominica may be home to at least three different species of *Sicydium* (Burback, 2010; pers obs.), including *S. buscki, S. plumieri* and *S. punctatum*, shown in figure 1. All three of these species feed on algae and may occur together at the same location. This raises the question: how do these sympatric species of *Sicydium* partition the same algal resource? It may be possible that they feed on algae in different ways. To investigate this further, I will specifically investigate whether there is a difference in the frequency of scraping in the different species of *Sicydium*.

Sicydium punctatum *Sicydium buscki* *Sicydium plumieri* (female)

Figure 1. Representative pictures of the three *Sicydium* species found in Dominica.

Methods

This study was conducted over the course of 17 days at four locations on rivers located throughout Dominica, including the Checkhall River, Castle-Bruce River, Belfast River, and Middleham Falls. At the Castle-Bruce, Belfast and Middleham Falls locations, individual gobies that were actively feeding on algae (scraping) were located via snorkeling. Once located, a video recording of a feeding event was obtained using a waterproof Nikon Coolpix digital camera. After recording, each video was checked immediately underwater to make sure that: (1) substrate scraping by the subject in the video was clearly visible; (2) a lateral view of the subject in the video was visible; and (3) to identify a scalable feature (usually a small pebble) adjacent to the subject in the video (to be used later for obtaining measurements).

The Checkhall River location included larger sized rocks where multiple gobies were feeding. At this location, a second method was also used to obtain measurements of feeding individuals. This method consisted of locating areas of rock where multiple gobies were feeding via snorkeling. Once an area was located, multiple 5 cm scorings were marked across the surface

of the rock. Once the rocks were marked, video recordings of feeding events were taken, making sure to capture a lateral view of each individual feeding close to the 5cm markings.

Video analysis was done by slowing down each video recording using the software Kinovea and making one-second clips of an individual feeding in order to count the number of scraping cycles completed within the span of 1 second. A screenshot of the lateral view of each individual along with the scalable feature (pebble or 1-cm mark on rock surface) was obtained. Each screenshot was examined using ImageJ (NIH) in order to calculate the head length (mouth to operculum) and total length (mouth to end of caudal fin) of each individual derived from the scalable feature visible in the image (i.e., pebble or a one-centimeter mark). Statistical analyses of the data were performed using the software JMP (SAS).

Results

A total of 13 videos were obtained, documenting the feeding events of 29 individual sicydiine gobies. The individuals recorded represented three different species, including *S. punctatum* (n=11), *S. plumieri* (n=5), *S. buscki* (n=11). Two of the individuals recorded could not be identified to species based on diagnostic characters and were referred to as “unknown”. A summary of the 29 videos, including species, sex, size and frequency of scraping of video subjects is provided in Table 1.

The total length range for *S. punctatum* was 22.0–71.2 mm, 32.3–117.0 mm for *S. plumieri*, and 42.4–71.0 mm for *S. buscki*. The head length range for *S. punctatum* was 3.9–13.5 mm, 8.0–25.3 mm for *S. plumieri*, and 9.8–16.2 mm for *S. buscki*. The range for scrapes per second for *S. punctatum* was 9–11, 2–6 for *S. plumieri*, and 3.5–6.5 for *S. buscki*. *Sicydium punctatum* had an average total length of 41.6 mm, an average head length of 7.4 mm, and an average of 9.9 scrapes per second. *Sicydium plumieri* had an average total length of 76.5 mm, an average head length of 17.6 mm, and an average of 3.9 scrapes per second. *Sicydium buscki* had an average total length of 56.4 mm, an average head length of 12.1 mm, and an average of 4.7 scrapes per second.

Table 1. Size and scraping frequency of *Sicydium* species sampled in freshwater streams in Dominica.

Individual ID	Species	Sex	Location	Total Length (mm)	Head Length (mm)	# scrapes/s
R	*S. buscki*	Female	Checkhall	59.673	13.2	6.5
T	*S. buscki*	Female	Checkhall	N/A	10.3	5
W	*S. buscki*	Female	Checkhall	49.448	12.2	5
X	*S. buscki*	Female	Checkhall	44.167	9.8	5.5
Y	*S. buscki*	Female	Checkhall	71.099	16.2	4.5
AA	*S. buscki*	Female	Checkhall	59.287	12.3	3.5
AB	*S. buscki*	Female	Checkhall	63.343	10.7	5
AC	*S. buscki*	Female	Checkhall	42.471	10.6	5
AD	*S. buscki*	Female	Checkhall	57.862	11.4	4.5
S	*S. buscki*	Male	Checkhall	57.191	13.3	4
U	*S. buscki*	Male	Checkhall	59.732	12.8	4
C	*S. plumieri*	Female	Belfast	93.691	17.7	4
D	*S. plumieri*	Female	Belfast	N/A	23.6	2.5
B	*S. plumieri*	Female	Castle Bruce	63.142	13.3	5
A	*S. plumieri*	Juvenile	Castle Bruce	32.389	8	6
F	*S. plumieri*	Male	Middleham	117.001	25.3	2
O	*S. punctatum*	Female	Checkhall	30.493	3.9	9
G	*S. punctatum*	Juvenile	Castle Bruce	28.881	5.2	10
H	*S. punctatum*	Juvenile	Castle Bruce	22.016	4.8	10
K	*S. punctatum*	Juvenile	Castle Bruce	39.737	7.9	10
Q	*S. punctatum*	Juvenile	Checkhall	40.487	5.8	9
J	*S. punctatum*	Male	Castle Bruce	28.921	5.9	11
L	*S. punctatum*	Male	Castle Bruce	68.118	12.6	9.5
M	*S. punctatum*	Male	Castle Bruce	48.378	8.1	10.5
N	*S. punctatum*	Male	Castle Bruce	71.22	13.5	11
P	*S. punctatum*	Male	Checkhall	38.837	6.5	10
V	*S. punctatum*	Male	Checkhall	40.986	7.8	9.5
Z	Unknown	Female	Checkhall	43.637	8.8	4.5
I	Unknown	Female	Castle Bruce	35.851	5.6	12

A significant difference was detected when a t-test was performed between the frequency of scraping between *Sicydium punctatum* and the other two species examined ($p<0.0001$). No significant difference was detected between the frequency of scraping between *S.buscki* and *S. plumieri* ($p = 0.1766$).

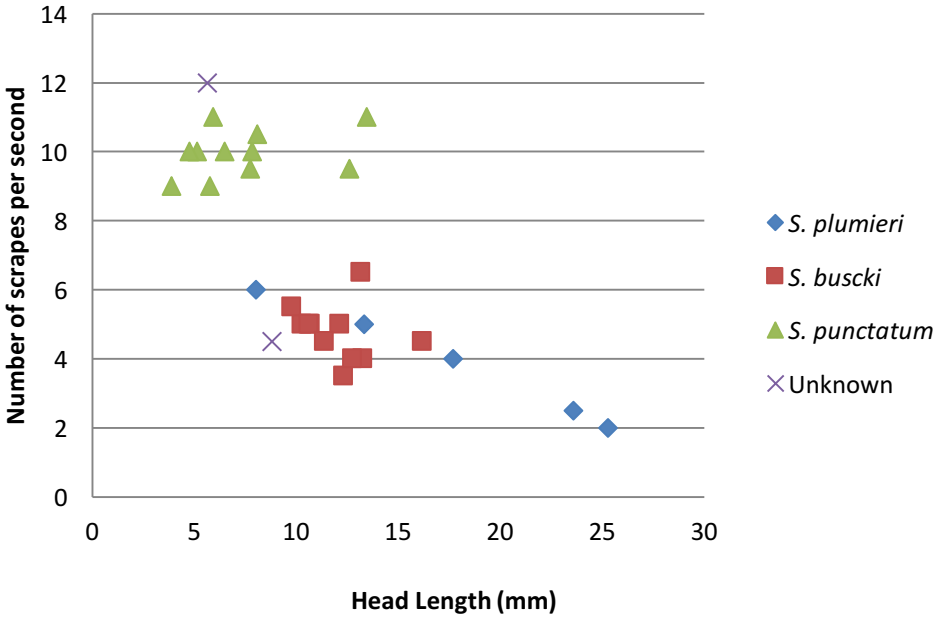

Figure 2. Frequency of scrapes plotted against head length (mm) for *S. punctatum* (n=11), *S. buscki* (n=11), *S. plumieri* (n=5), and unknown (n=2). Both *S. punctatum* and *S. buscki* have a smaller range in head length compared to *S. plumieri* (3.9–13.5 mm, 9.8–16.2 mm, and 8.0–25.3 mm respectively). *S. plumieri* has the largest range in scraping frequency (2-6 scrapes per second) and has a decreasing scraping frequency as the head length of the individual increases. The unknown individuals can be identified as one of the species documented based on their scraping frequency.

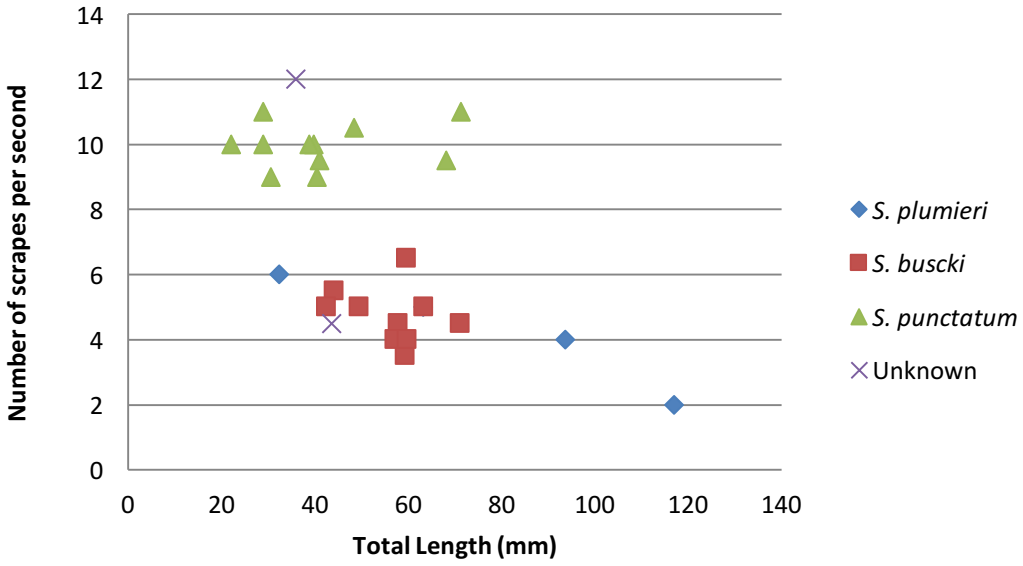

Figure 3. Frequency of scrapes plotted against total length (mm) for *S. punctatum* (n=11), *S. buscki* (n=11), *S. plumieri* (n=5), and unknown (n=2). Both *S. punctatum* and *S. buscki* have a smaller range in total length compared to *S. plumieri* (22.0–71.2 mm, 42.4–71.0 mm, and 32.3–117.0 mm respectively). *S. plumieri* has the largest range in scraping frequency (2-6 scrapes per second) and has a decreasing scraping frequency as the total length of the individual increases. The unknown individuals can be identified as one of the species documented based on their scraping frequency.

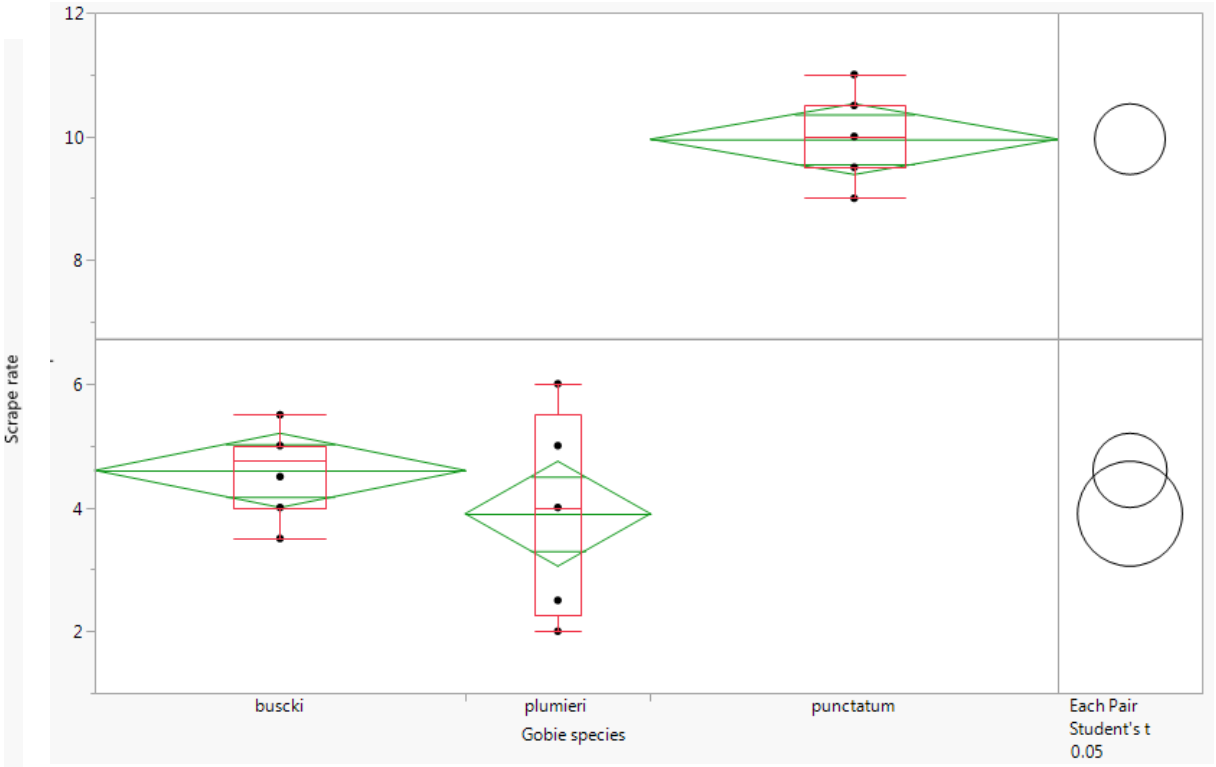

Figure 4. Box plot of frequency of scrapes by species of goby. *Sicydium punctatum* is significantly different from *S. plumieri* and *S. buscki* ($p < 0.0001$). There is no significant difference between *S. plumieri* and *S. buscki* ($p = 0.1766$). *Sicydium punctatum* has a scraping frequency range of 9–11 scrapes per second and an average of 9.9 scrapes per second. *Sicydium plumieri* has a scraping frequency range of 2–6 scrapes per second and an average of 3.9 scrapes per second. *Sicydium buscki* has a scraping frequency range of 3.5–6.5 scrapes per second and an average of 4.7 scrapes per second.

Discussion

Based on the frequency of scrapes for each species, the two unknown species, shown in figures 2 and 3, fall into categories already set. The unknown individual "I" falls within the *S. punctatum* group while the unknown individual "Z" falls within the *S. buscki* group. Therefore, the two unknown individuals I and Z can be identified as *S. punctatum* and *S. buscki* respectively.

There was a significant difference in scraping frequency between *S. punctatum* and *S. buscki* as well as with *S. punctatum* and *S. plumieri* (Fig. 4). There was no significant difference between *S. plumieri* and *S. buscki* (as they fall within similar ranges of scraping frequencies).

The three species of *Sicydium* fishes, *S. punctatum*, *S. plumieri*, and *S. buscki* have different average scraping rates during feeding events (Fig. 2 & Fig.3). *Sicydium plumieri* has a decreasing scraping frequency as the size (total length and the head length) of the individual

increases while the other two species (*S. punctatum* and *S. buscki*) tend to stay within a certain range of scraping frequency. *Sicydium punctatum* is significantly different from *S. plumieri* and *S. buscki*. *Sicydium punctatum* and *S. buscki,* which look fairly similar, can be identified as one or the other based on their frequency of scrapes. One question that could be answered by further study is whether *S. punctatum* and *S. buscki* have a lower scraping rate as their size increases.

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