An Analysis of Fish Interactions in Cleaning Symbiosis

Mich Dupré
Min Kocher

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Prof. John Gilbert

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ABSTRACT

This study describes fish interactions at cleaning stations. We examined invitation poses by host species, preferences by cleaners toward the hosts, length of time spent by the host in the station, response to disturbances, and Damselfish interactions. We expected that preferred hosts would spend less time posing and would receive cleaning for a longer time and by more cleaners. We also expected that time spent at station would vary by species in terms of its risk to predation. We also expected regular successional patterns of behavior after disturbances, and that Damselfish would aggressively interact with threatening cleaner fish. We found that Bluehead Wrasse juveniles exhibited preferences for parrotfish by moving faster to them, cleaning them longer, and in greater numbers. Cleaners also prefer larger Creole wrasses to smaller ones. Different species spend significantly different amounts of time in the station. We also observed an orderly succession of events to reestablish a station after a disturbance. Damselfish left the cleaner fish alone unless their coral head territory was invaded.

INTRODUCTION

Many organisms exhibit the phenomenon known as cleaning symbiosis, a mutually beneficial relationship providing food for the cleaner and well-being for the host by removing parasites and/or detritus. This remarkable behavioral adaptation is well documented terrestrially, but relatively little research has been done on aquatic systems. Further study is important because cleaning symbiosis could be quite significant to the marine ecosystem. For example, Conrad Limbaugh (1961) removed all of the cleaning fish from a reef and found a marked reduction in the overall fish population, and the remaining fish exhibited poor health (e.g. diseased, frayed fins, ulcerated sores.)

In the waters near Discovery Bay, Jamaica cleaning symbiosis is a common occurrence. The following fish species have been observed as cleaners: *Bluehead wrasse juveniles, *Cleaning goby, Spanish hogfish juveniles, and Bicolor damselfish juveniles. The following have been observed as host species: *Creole wrasse, *Stoplight parrotfish, *Princess parrotfish, *Striped parrotfish, Yellowhead wrasse, Red hind, Blue chromis and Blue tang (* - most common.)

In order to gain further insight into this fascinating behavior, we examined fish interactions at cleaning stations. Specifically, we compared invitation poses between different species. We also studied preferences by cleaners towards hosts in terms of host species, size and host group size. We hypothesized that preferred hosts would need to spend less time posing and would receive cleaning for a longer time and by more cleaners. In addition, we observed the total time spent by the hosts at the stations. We hypothesized that this time would vary by species in terms of its risk ~~to~~ of predation while being cleaned.

Other fish often interact with these cleaning stations. For example, some fish such as Indigo hamlets, jacks and trumpetfish cause the stations to be dispersed. By observing both natural and artificially induced disturbances, we hypothesized

that regular successional patterns of behavior will occur in order to reestablish the cleaning station. Another major interaction occurs with Damselfish. Often times the cleaning stations are found in their territories. We hypothesized that Damselfish would aggressively interact with cleaning fish when they posed a threat toward their territories (i.e. feeding.)

METHODS

This study was conducted over an 8-day period (2/27/89-3/6/89) at the fringing coral reef of Discovery Bay, Jamaica. All observations were made in the vicinity of Mooring 1, with a total data collection time of 10 hrs. 30 min. in 12 dives with SCUBA.

Data collection was done at six cleaning stations with the bulk of the data coming from two of these stations. All six of these stations occurred around coral heads in 35-50 ft. of water. Five of these six stations occurred in damselfish territories. All six of these stations remained at the same place during the study period.

We observed invitation poses of different host species. In order to investigate cleaner preference for hosts, we measured pose time, cleaning duration, and number of cleaners on host. We defined "pose-time" as the time between when the host first strikes a pose to when it is cleaned. We defined "cleaning duration" as the time the cleaners spent cleaning the host. We also looked at the total time spent at the cleaning station, which we defined to be the time between entering and leaving the cleaning station vicinity, including cleaning time. We analyzed pose time, cleaning time, and total time for three host fish species: Creole wrasse, Striped/Princess Parrotfish, and Stoplight parrotfish. We further analyzed cleaning duration and number of cleaners for fish size (large Creole wrasse vs. ~~small~~ average-sized Creole wrasse) and group size (Creole wrasse in large groups (15-20) vs. small groups (0-5)).

We observed natural disturbances of the cleaning stations and created disturbances by swimming through stations while screaming and brandishing a dive knife. After the disturbance, we measured time to the return of the Bluehead wrasse cleaning fish to the top of the coral head, the return of the first host fish, and the return to the predisturbance number of hosts. Finally, we noted incidents of damselfish aggression towards fish in the vicinity of the cleaning station.

RESULTS

Part I : Invitations to Clean

Host fish waiting to be cleaned strike a variety of poses to "invite" the cleaner fish to remove their parasites and detritus. In our observations, Creole wrasses most often positioned themselves head down at an angle between 45 and 90 degrees (Figure 1.) However, on occasion we did see them lie on their sides so that the cleaners could reach their pectoral fins. Stoplight, Princess, and Striped parrot-fish all posed with their heads up (Figures 2 and 3.) Many times these fish did not need to pose because the Bluehead wrasse juveniles would begin cleaning as they swam through. Blue tangs simply stopped in the station keeping the same position as when swimming (Figure 4.) On the other hand, the Red hind strategically positions itself between the corals, holding itself into place with its pectoral fins. The cleaner gobies are then easily able to move from coral head on to the hind's body (Figure 5.)

Figure 1 : Creole Wrasse (*Clepticus parrai*) and Bluehead Wrasse juveniles (*Thalassoma bifasciatum*).

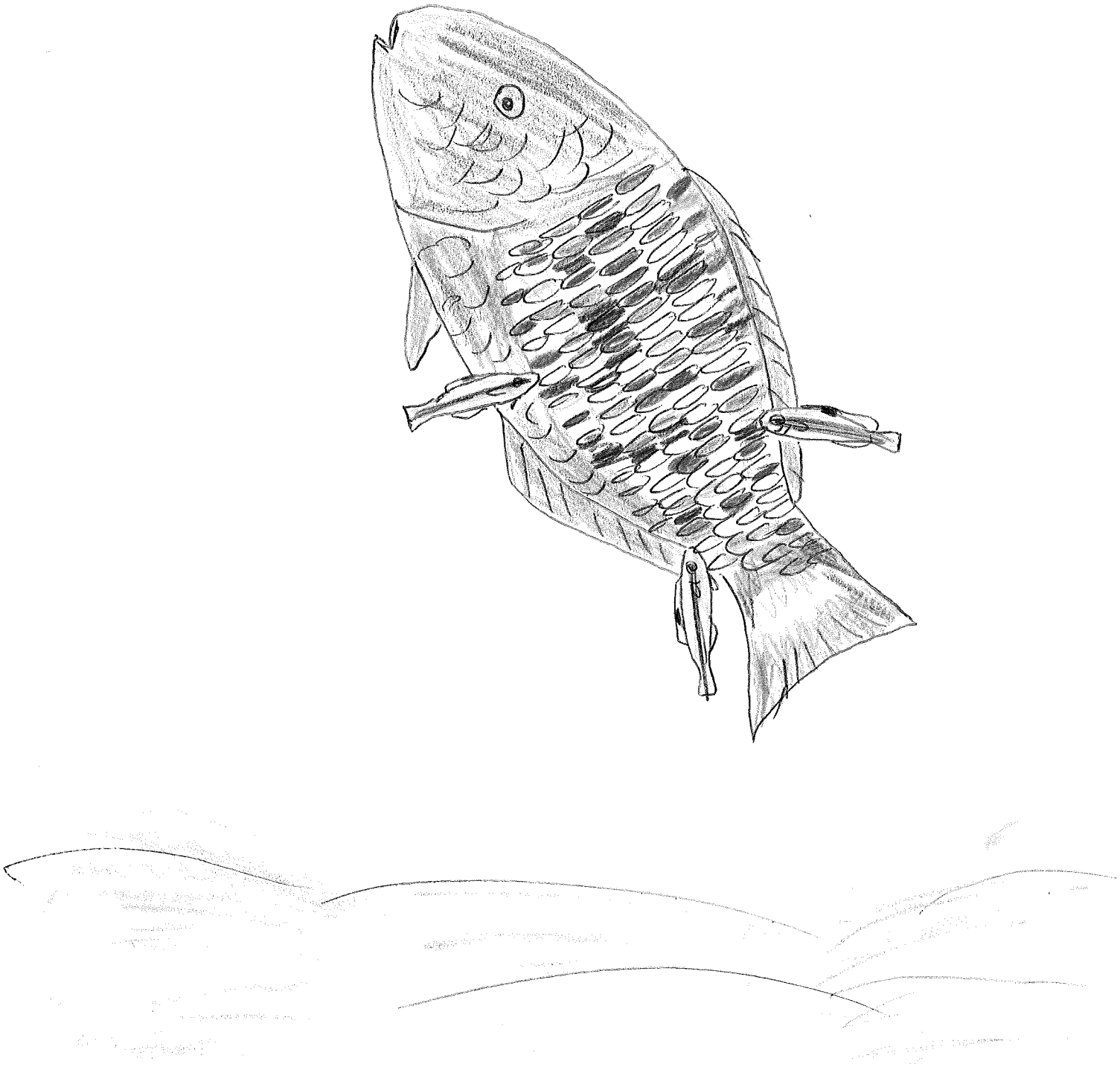

Figure 2: Stoplight Parrotfish (*Sparisoma viride*) and Bluehead Wrasse juvenile (*Thalassoma bifasciatum*)

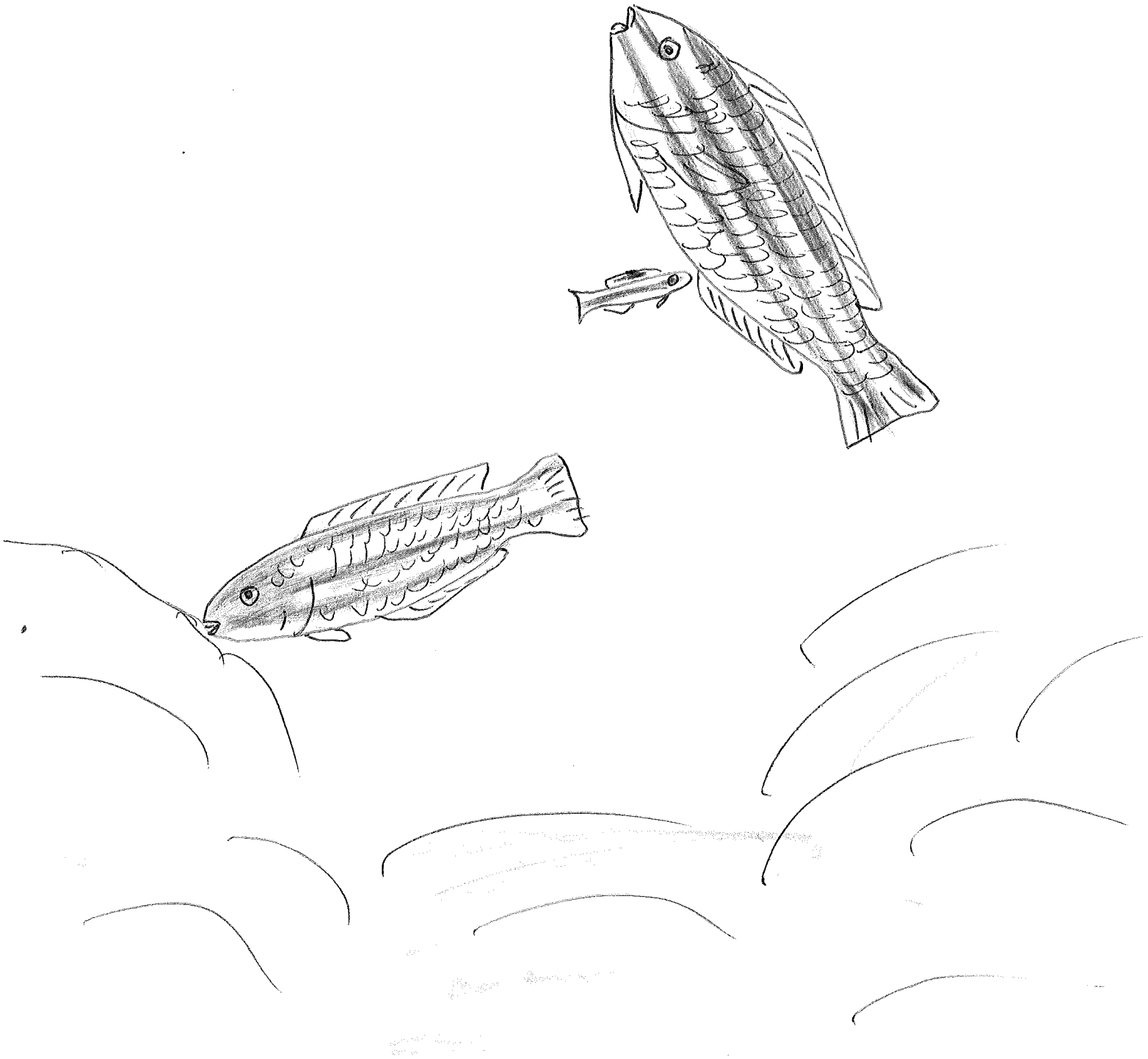

Figure 3: Princess Parrotfish (*Scarus taeniopterus*) and Bluehead Wrasse juvenile (*Thalassoma bifasciatum*). Striped Parrotfish (Scarus croicensis) feeding.

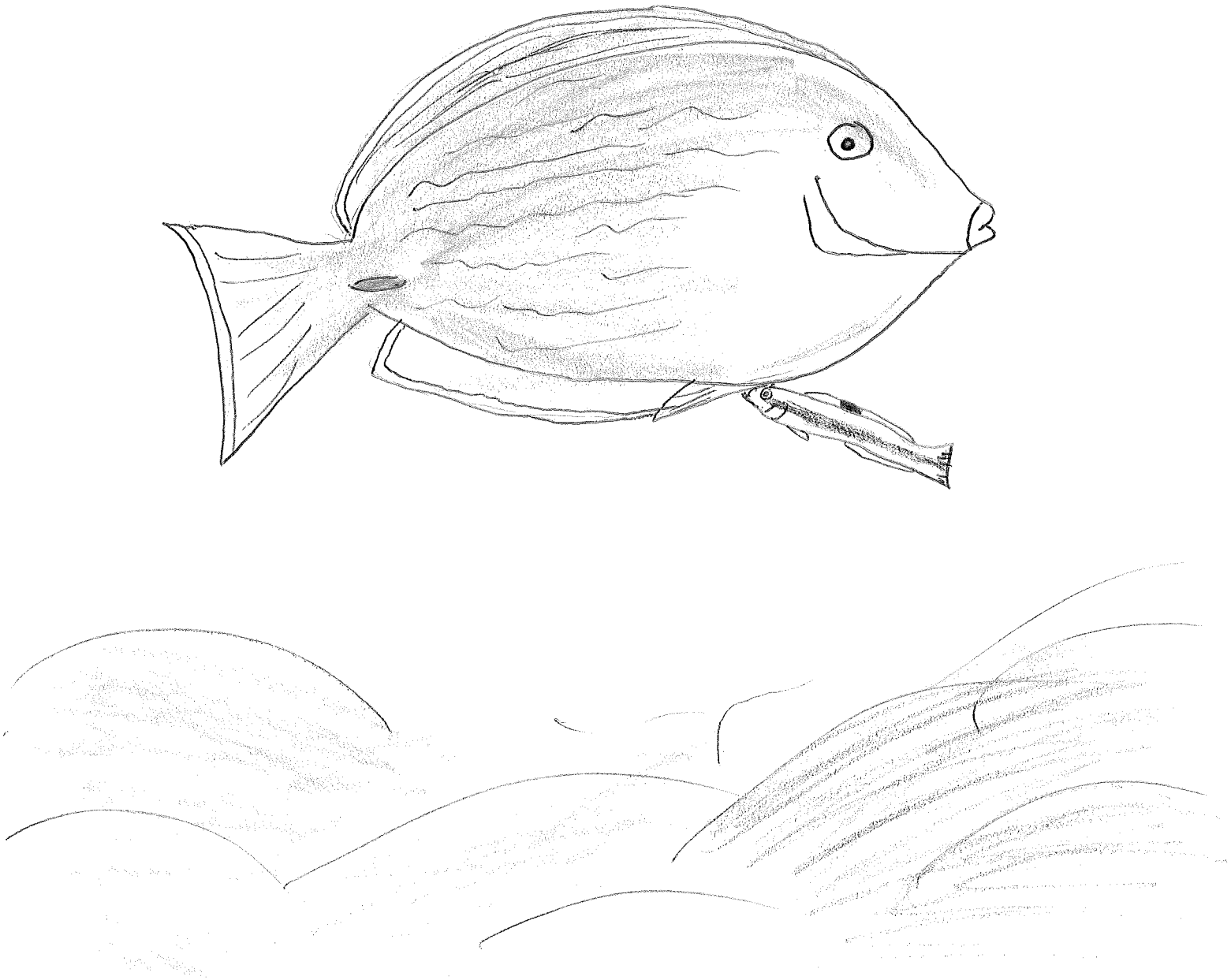

Figure 4: Blue Tang (*Acanthurus coeruleus*) and Bluehead Wrasse juvenile (*Thalassoma bifasciatum*).

Figure 5: Red hind (*Epinephelus guttatus*) and Cleaning goby (*Gobiosoma genie*.)

Results

Part II : Pose Time

Table 1 shows that stoplight parrotfish have the shortest (.43 sec) pose time, then Striped and Princess parrotfish (1.52 sec). Creole wrasses spent the longest time in a pose before being cleaned (4.6 sec.). Using t-tests there was a significant difference between the three compared species. (Table 1.5.) We had insufficient data to compare tangs, chromis, Redhind and Yellowhead wrasse fish.

Should have used ANOVA

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Part II: Pose Time

Species	Sample Size	Average Pose Time	Standard Deviation
Creole Wrasse	41	4.60 sec.	3.13
Stoplight Parrotfish	7	0.43 sec.	0.38
Striped/Princess Parrot.	15	1.52 sec.	1.11

Table 1: Average pose time for different host species. "Pose time" is the time between first striking a pose and being cleaned.

T-test	t-value	degrees of freedom	P-value
Stoplight Parrot vs Creole Wrasse	3.52	46	<.01
Creole Wrasse vs Princess/Striped P.	3.73	54	<.001
Stoplight Parrot vs Princess/Str. Parrot	2.53	20	<.02

Table 1.5: Results from t-tests show significant results for comparing pose times for different species.

use ANOVA

Results

Part III: Clean Duration and Number of Cleaners

In terms of clean duration (table 2), cleaners spent significantly less time cleaning Creole wrasse than either Princess/Striped parrotfish ($t = -8.59$, $p < 0.001$) or Stoplight parrotfish ($t = -10.04$, $p < 0.001$). Princess/striped parrotfish did not significantly differ from stoplight parrotfish in terms of cleaning duration ($t = 1.73$, $p > 0.05$). Cleaners also spent significantly more time cleaning large Creole wrasse than average-sized Creole wrasse ($t = 6.92$, $p < 0.001$). We found no significant difference in cleaning duration between creole wrasse in large host groups and Creole wrasse in small host groups ($t = -0.587$, $p > 0.05$).

In terms of number of cleaners (table 2), Creole wrasse were cleaned by significantly fewer cleaners than either Princess/striped parrotfish ($t = -10.05$, $p < 0.001$) or Stoplight parrotfish ($t = -16.98$, $p < 0.001$). Also, stoplight parrotfish were cleaned by significantly more cleaners than Princess/striped parrotfish ($t = 3.63$, $p < 0.01$). There were no significant differences found in number of cleaners for either large vs. average-sized Creole wrasse ($t = 1.48$, $p > 0.05$) or Creole wrasse in large vs. small groups ($t = -0.41$, $p > 0.05$).

Figures 6 + 7 display bar graphs of mean clean duration and number of cleaners for species, fish size, and group size categories.

TABLE 2: Clean Duration and Number of Cleaners Data for Three Fish Species, Fish Size and Group Size.

ANALYSIS		n	CLEAN DURATION $\bar{X}$ (seconds)	CLEAN DURATION σ	# of CLEANERS $\bar{X}$	# of CLEANERS σ
Species:	Creole Wrasse	57	1.25	0.82	1.04	0.19
	Princess + Striped Parrotfish	15	6.57	4.40	2.33	0.90
	Stoplight Parrotfish	15	10.05	6.42	3.67	1.11
Fish Size:	Large Creole Wrasse	8	2.63	0.94	1.13	0.35
	Average Creole Wrasse	49	1.02	0.54	1.02	0.14
Group Size:	C.W. - Large Group (15-20)	10	1.20	0.74	1.00	0.00
	C.W. - Small Group (0-5)	25	1.40	0.94	1.08	0.28

use ANOVA

Figure 6: Mean Clean Duration and Number of Cleaners for Creole Wrasse: Large vs Small Creole Wrasse and Creole Wrasse in Large vs Small Groups.

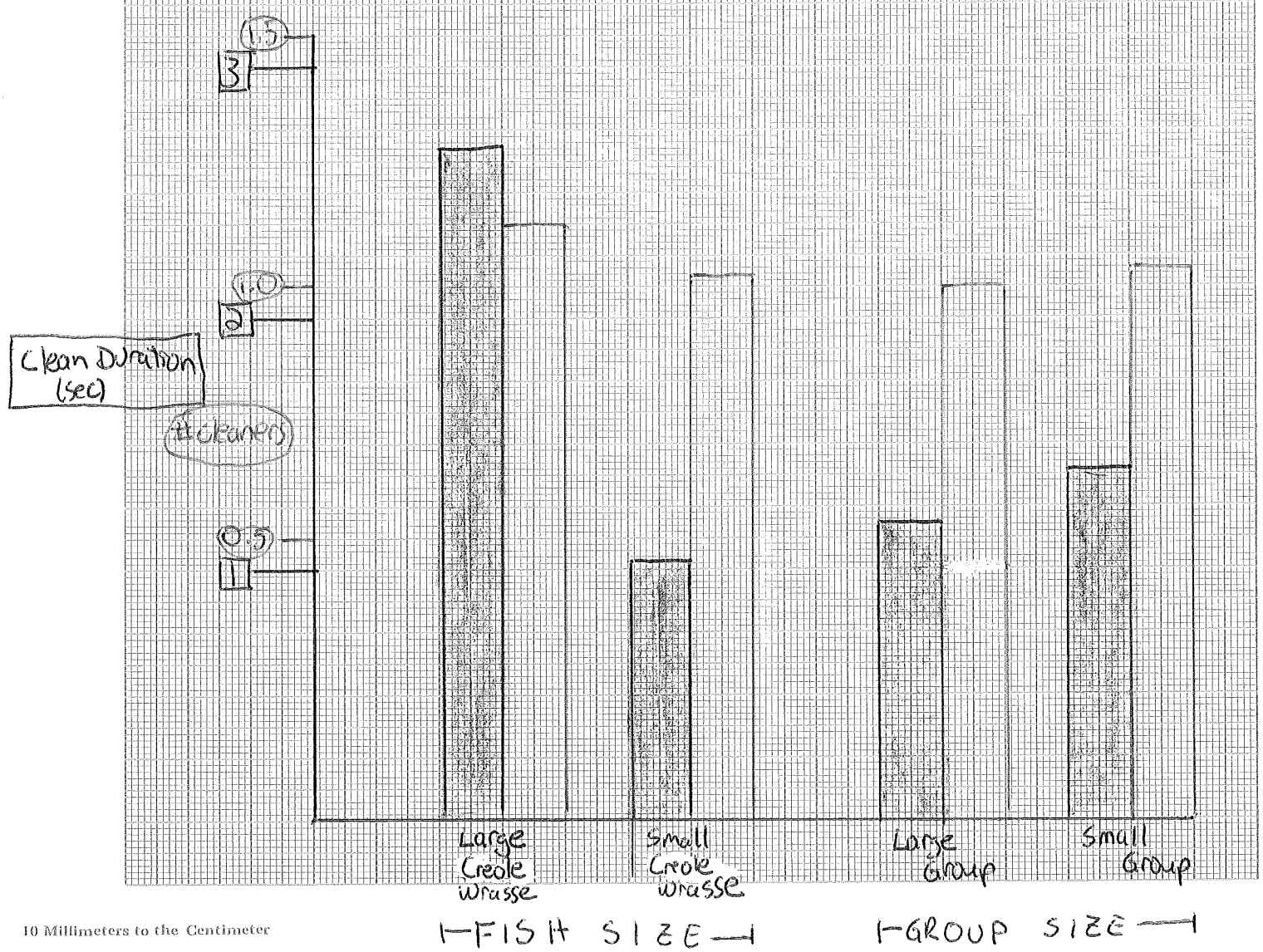

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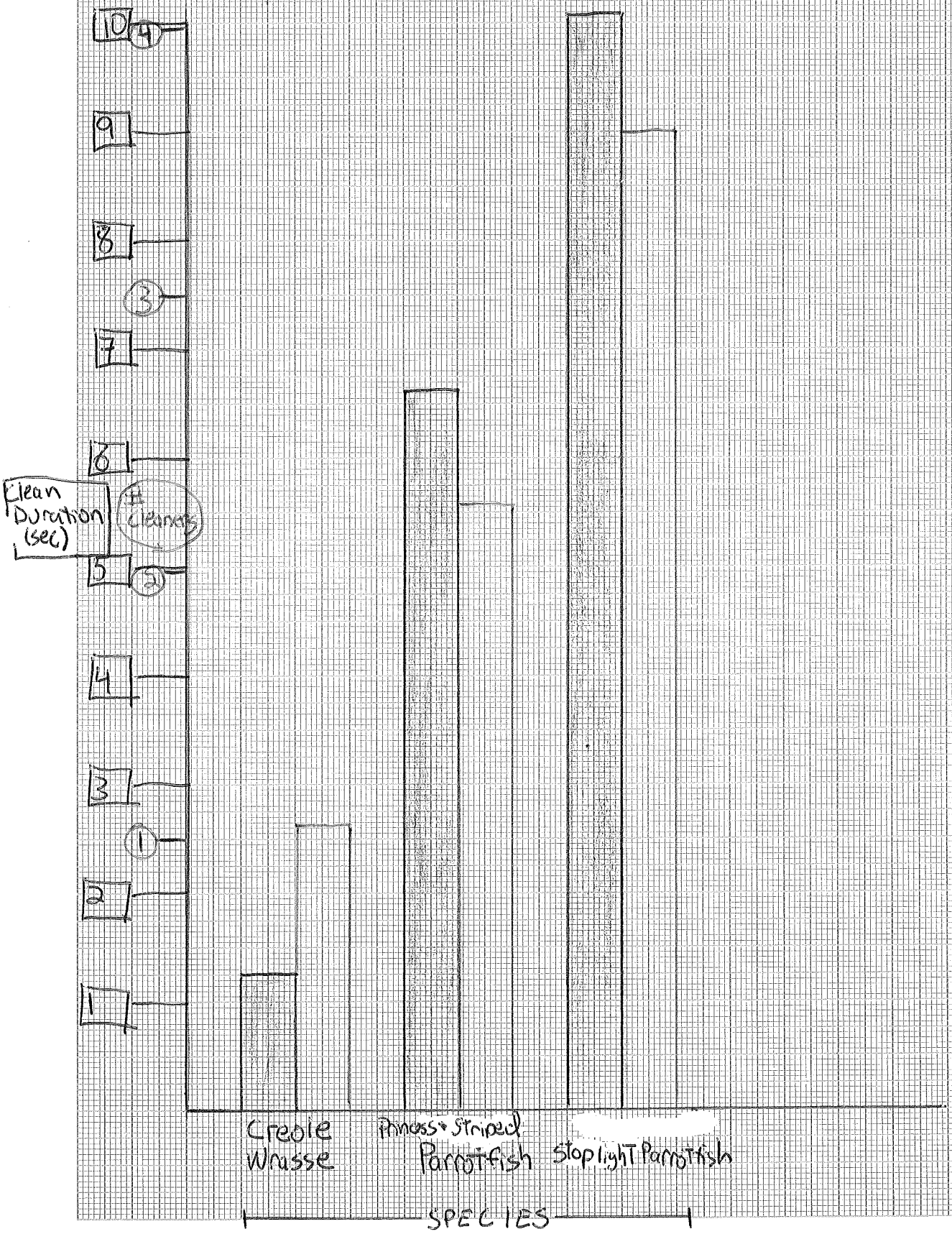
Figure 7: Mean Clean Duration and Number of Cleaners for Creole Wrasse, Stoplight Parrotfish, and Princess and Striped Parrotfish



Results

Part IV: Total Time Spent at Station

Comparing the total time spent by individual fish at a cleaning station shows great variability between species. Table 3 shows that Stoplight and Striped/Princess parrot-fish spend the least time. Their average times were 8.4 and 10.3 seconds respectively. Many times these species just swam through the station, and they often fed on the coral in the area. Similarly, Blue tang spent a relatively short time in the station (12.5 seconds) Creole wrasses spent an average of 41.9 seconds, while the one observed Red hind spent a total of 23:17. minutes.

Using a G-test for frequency distribution to compare the total time spent in the station for the Creole wrasse, Stoplight parrotfish and Princess/Striped parrotfish we found a ~~a~~ significant difference between the different species ($G = 27.96$, $p \ll 0.001$). Table 4 and Figure 8 show that all of the Princess/Striped parrotfish and 89% of the Stoplight parrotfish spend less than 20 seconds at the cleaning station. Whereas, the amount of time spent for the Creole wrasses was more evenly distributed between 7 seconds and 3 minutes.

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Part IV: Total Time spent at Station

Species	Sample Size	Average Total Time at Station	Standard Deviation
Stoplight Parrotfish	10	8.4 sec	10.5
Striped/Princess Parrotfish	7	10.3 sec	7.7
Blue Tang	4	12.5 sec	8.9
Creole Wrasse	29	41.9 sec	41.4
Red Hind	1	23:17 min	—

Table 3: Average total time spent at station for different host species. "Total time" is the time between entering and leaving the area, including cleaning time.

10 Millimeters to the Centimeter

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Part IV : Total Time Spent at Station

Key	Fish Species	Time spent at station (seconds) 0-20	20-40	40-60	>60
	Creole Wrasse	7	12	6	4
	Stoplight Parrotfish	8	1	0	0
	Princess and Striped Parrot.	9	0	0	0

Table 4: Comparative analysis of total time spent at cleaning stations between Creole Wrasse, Stoplight Parrotfish, and Princess and Striped Parrotfish.

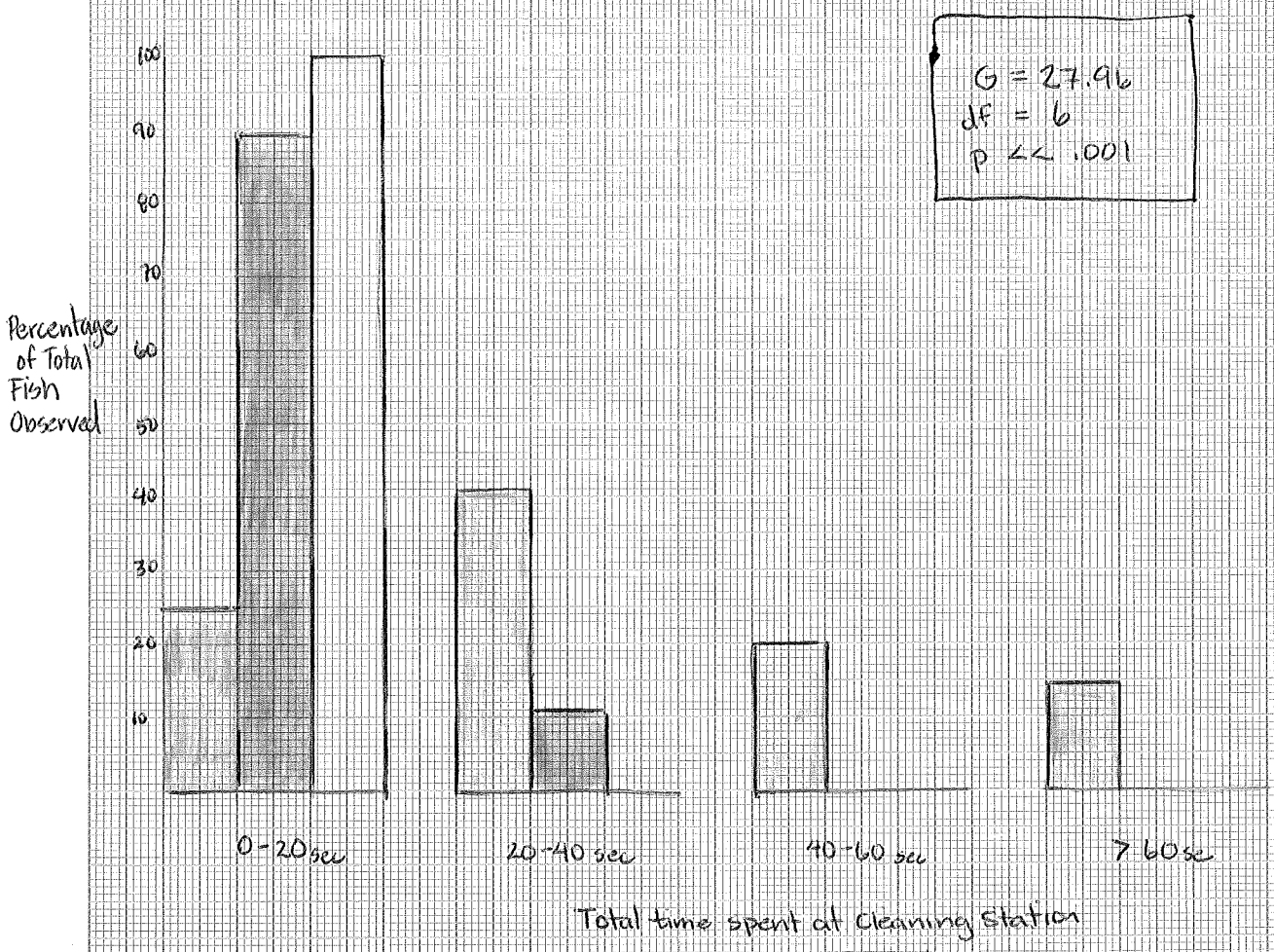

Figure 8: Species frequency distribution vs. total time spent at cleaning station.

10 Millimeters to the Centimeter

Results

Part V: Disturbances

Cleaning stations were occassionally disrupted by the intrusion of certain fish. Whereas some fish species could swim very close to the station without instigating a disturbance, the presence of other fish species seemed to disrupt the station. Fish that were observed causing a disturbance were Bar jacks, Yellow jacks, Yellowtail snapper, Indigo hamlets, Red hinds, and Trumpet fish.

A disturbance was characterized by the rapid dispersal of both the hosts and the cleaners. The hosts usually dispersed upwardly, away from the coral head, with the Creole wrasse usually rejoining the large, diffuse school overhead. The cleaning gobies never left the coral head. Instead, they would reorient themselves away from the disturbance while remaining on the coral. On the other hand, the Bluehead wrasse cleaners would usually disperse downwards into the coral head. They were often observed to be feeding around the coral during the time interval immediately after the disturbance. There were many instances of damselfish aggression towards the Bluehead wrasse at this time. Also during this time, other fish, especially parrotfish, would move onto the coral head and feed. Shortly after the disturbance, the Bluehead wrasse would then return to the top of the coral head and bob around. Next, a host fish, almost invariably a Creole wrasse, would return.

This succession was fairly constant. Upon disturbing 15 cleaning stations, we found the mean time for: ① the return of the Bluehead wrasse to the coral head to be 9.0 seconds (s.d. 6.6), ② the return of the first Creole wrasse to be 38.4 seconds (s.d. 22.6), and ③ the return of the predisturbance number of hosts to be 82.3 seconds (s.d. 22.8).

Results

Part VI: Damselfish Interactions w/ Cleaning Stations

Five of the six cleaning stations we studied were in damselfish territories. We observed damselfish aggress against Stoplight parrotfish, Princess parrotfish, Striped parrotfish, Rock hinds, Blue Tangs, Rock beauties, and Clown wrasse that were in the vicinity of the cleaning station. In addition, damselfish were observed to interact aggressively with the cleaning fish.

We observed 22 incidents of damselfish aggression upon Bluehead wrasse and no incidents of aggression upon Cleaning gobies. All 22 of these interactions occurred when the Bluehead wrasse were not cleaning hosts, and many of them occurred when the Bluehead wrasse were feeding around the coral head. In over half of these interactions (14/22), there were no hosts in the area of the cleaning station.

In the one station which was not in a damselfish territory, we qualitatively noted a difference in the species composition of the hosts. There were many more Blue tangs and parrotfish being cleaned.

DISCUSSION

Different host species exhibit markedly different invitation poses. These varying poses enable the cleaning fish to gain easy access to different parts of the host's body. For example, Creole wrasse pose in a head-down manner as to expose their dorsal, anal, caudal, and pelvic fins, whereas they lie on their sides as to expose their pectoral fins. Positioning may also be a factor of predation pressure. For example, the red hind cryptically poses within the coral head itself.

We found distinct trends in cleaner preferences for hosts. Our results comparing pose time for different host species show that Bluehead wrasse cleaning fish exhibit the greatest preference for Stoplight parrotfish, then Princess/Striped parrotfish, and then Creole wrasse. We did not have enough data to statistically compare preferences for other host species such as Blue tangs, Blue chromis, Yellowtail wrasse, and Red hinds.

Our results comparing clean duration and number of cleaners elucidate similar species preference trends. Stoplight parrotfish were cleaned longer and by more cleaners. Next in this preference hierarchy came Striped/Princess parrotfish and, once again, the Creole wrasse was the least preferred host species. We also found a preference for large Creole wrasse over average-sized Creole wrasse with the clean duration data. The size of the host group did not seem to be related to any cleaning fish preference. Very interesting and revealing further study in this area could correlate these host species and size preferences with ectoparasite quantity (or quality) by catching and examining host fish.

Total time spent at the cleaning station varied with host species. These patterns might be related to risk of predation while being cleaned. The Creole wrasse spent much longer at the cleaning station as compared to the parrotfish and Blue tangs. We suspect that this is due to their schooling behavior which affords them protection. On the other hand, the parrotfish and the tangs do not enter the station in groups and, thus, enter + leave the

station more quickly. Interestingly, the parrotfish and Blue tang feed on the corals in the station. So while they might be more vulnerable to predators, they have the advantage of being able to forage while they wait. One unexpected observation was the Red hind that entered the station and stayed for 23 minutes while being cleaned by the gobies. We believe that this fish could stay for such a long time and be protected from predators by strategically positioning itself within the coral head and cryptically changing its color. These trends are further supported by comparing the species frequency distribution vs. total time spent at the cleaning station. Almost all of the parrotfish leave the station within 20 seconds whereas the Creole wrasse distribution lingers until more than one minute.

The disposal and reformation of cleaning stations seems to be an integral part of their existence. These stations reform, at the same place, after every night. They also reform after disturbances. We found this reformation to be an orderly behavioral succession where the hosts and cleaners all disperse. The Bluehead wrasse come back atop the coral head and bob around for a while. After this, the host fish return. This orderly and linked succession of events can provide insights into the cues that hosts are using to locate cleaning stations. We never observed a Creole wrasse return before the Bluehead wrasse appeared atop the coral head. Perhaps the host fish rely on visual cues of the brightly colored, bobbing Bluehead wrasse to locate the cleaning station. Further study in which models of cleaning fish were constructed and displayed would be interesting in terms of gaining insights into how host fish find cleaning stations.

Five of our six stations occurred in damselfish territories. Our results suggest that the damselfish adopt a "live and let live" policy with the cleaning stations until their coral head territory is invaded by feeding Bluehead wrasse. Most of the host fish are not threats to the damselfish, due to small dietary overlaps, and those that are threats do not tend to stay at the station for long periods of time. It was very interesting to note a qualitative difference

in host species composition at the one station that was not in a damselfish territory. At this station, many Blue tangs and parrot fish were getting cleaned. Perhaps the absence of a damselfish allows these host species, which might otherwise have been aggressively excluded, to remain at the cleaning station. Further study might elucidate the effect of damselfish on host species composition.

In conclusion, we have gained much knowledge into the dynamics of cleaning stations. Still, much remains to be learned about this remarkable symbiosis.

Nick/Mia,

An exceptionally fine and innovative study! Excellent design, data, data analysis and presentation, and discussion.

A+

John

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