

## **Site fidelity, coral type fidelity and coral type preference for the Humbug Damselfish, *Dascyllus aruanus***

### **Abstract**

This study took place in the lagoon in front of Public Beach, Moorea, French Polynesia. We investigated the fidelity of the juvenile humbug damselfish, *Dascyllus aruanus* as a function of treatment and location. Treatment is represented by two types of coral species and location by using two study sites. Additionally, selective behavior of *D. aruanus* between the two coral species was investigated. We transplanted *P. verrucosa* and *P. lobata* coral heads to the two study sites, stocked the corals with 5-8 juvenile humbugs, and counted them daily. We found that juvenile *D. aruanus* preferentially stayed on *P. verrucosa* versus *P. lobata* and that there was no difference in coral type fidelity between the two study sites.

### **Introduction**

Spatial variation in distribution of fish species can be attributed to many different factors including current, temperature, habitat availability, competition (Carr, 2002), larval supply, recruitment (Baker, 2000) and post-settlement mortality (Caselle, 1996; Schmitt, 1996). Moreover, fidelity may contribute to spatial variation in distribution of the humbug damselfish, *Dascyllus aruanus*. We suspect that juvenile humbug damselfish prefer branching coral versus an encrusting columnar coral even though adult humbugs are found on both coral species. During a preliminary study, juvenile humbugs were observed on *Porites lobata* and *Montipora sp.* in addition to *Pocillopora verrucosa*.

Throughout the Indo-Pacific, the humbug damselfish is a popular study species (Sale, 2001). Forrester has looked at density dependent mortality of *D. aruanus* (Sale, 2001), interspecific competition has been studied (Schmitt and Holbrook, 1999), and Jones looked at intraspecific competition (Sale, 2001). In this study, we wanted to investigate fidelity of the humbug damselfish in relation to location and treatment. More specifically, we wanted to

examine spatial variation in distribution of humbugs considering site fidelity, coral type fidelity within a site, and coral type preference as a function of behavior for juvenile humbug damselfish.

Though other studies have already looked at habitat preference (Baker, 2000; Schmitt and Holbrook, 1999), this study is important in terms of conservation efforts of the coral reef. It seems that certain fish species prefer specific habitats, i.e. *D. aruanus* prefers live branching corals in the near shore lagoon, as *D. trimaculatus* and *Amphiprion chrysopterus* prefer anemones (Schmitt and Holbrook, 1999). Protection of unique habitats is important because anthropogenic impacts could lead to extinction of certain coral species. This may result in a decrease in habitat availability and possibly lead to a decline in a fish species population utilizing a unique habitat.

The pattern we observed is spatial variation in the distribution of *D. aruanus* at the fringing patch reef compared to the crest patch reef in the lagoon in front of Public Beach, Moorea, French Polynesia. We observed that settlers exhibit a strong preference for branching coral *P. verrucosa* versus the massive encrusting coral *P. lobata*. Additionally, abundances of *D. aruanus* seemed higher at the fringing patch reef closer to shore than at the crest patch reef further from shore. Habitat preference could be due to the branching morphology of *P. verrucosa*, compared to the encrusting columnar morphology of *P. lobata*. Though not significant ( $p = 0.269$ ), the results of our pilot study suggest that the abundance of humbugs is higher on *P. verrucosa* than on *P. lobata* in the lagoon in front of Public Beach. The observation that adult humbugs are found on different coral types made us speculate whether juvenile fidelity differed between coral types.

The goal of our study was to test the idea that fidelity of humbugs varies as a function of location and treatment, where two different study sites represent location, and two different coral

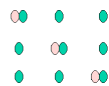
types represent treatment. Furthermore, we wanted to test whether coral selection behavior is different as a function of location and treatment. We investigated if fidelity is greater on *P. verrucosa* than on *P. lobata* at two different locations, the near-shore lagoon and the outer lagoon. Furthermore, we investigated if selection behavior causes higher abundance of juvenile *D. aruanus* on *P. verrucosa* than on *P. lobata* at two different locations.

**Materials and Methods**

*Study site*

In order to determine the fidelity of juvenile humbugs as a function of location (site 1 and site 2) and treatment (*P. verrucosa* and *P. lobata*), our study took place in the lagoon in front of Public Beach on the island of Moorea, French Polynesia (Site 1: S17°29 298', W149°50 973'; Site 2: S17°29 101', W149°50 310'). Water depth ranged from 1.5 to 3m, with a southwest current flowing through the crest patch reef and the fringing patch reef. One of our sites was along the

fringing patch reef area, which was closer to the beach, and the other site was along the crest patch reef, further from shore (Fig. 1).



Site 2: Outer lagoon



Site 1: Inner Lagoon

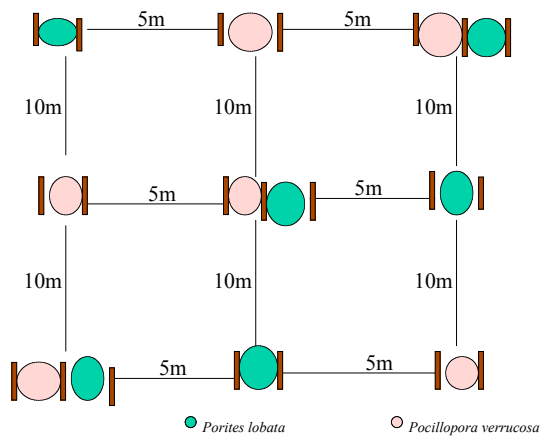
**Figure 1.**  
Study site 1 and 2

*Species description*

The humbug damselfish, *Dascyllus aruanus*, is commonly found in the lagoon of Moorea, French Polynesia. Adult humbugs are broadcast spawners and their pelagic larval duration is approximately 24-25d (Sale, 2001; Loyat, 2002). When the humbug larvae, 9-10mm in size, return to the lagoon, they preferentially settle on branching corals, such as *Pocillopora eydouxi* and *Pocillopora meandrina* (Baker, 2000). Adult humbugs use live branching corals for shelter, yet are not associated with a specific coral head. Humbugs tend to survive better at sites closer to shore (Jones, 1997).

### General methods

The experiment was a matrix of three rows parallel to shore, each with three replicates of coral heads. The coral heads were separated by 5m and the rows were 10m apart (Fig. 2). The



coral heads were supported by rebar on either side and held in place with cable ties. All the coral heads had volumes of about 0.0156 m<sup>3</sup>. 18 replicates (12 single coral heads and 6 double heads) were stocked with 5 to 8 juvenile *D. aruanus*. Fish were counted daily from November 19 to December 2, 2002 using

SCUBA.

**Figure 2**  
Coral arrangement within a site

### Fidelity as a function of treatment and location

In order to determine fidelity of juvenile humbugs as a function of treatment, each row had a branching coral, *P. verrucosa* and a massive encrusting coral, *P. lobata*. There were 6 single coral heads per site, for a total of 12 single coral heads. All corals were initially cleared of fish when transplanted to the two sites, then stocked with 5 to 8 *D. aruanus*. To compare the fidelity of *D. aruanus* in relation to location we had two study sites. Site 1 was near the fringing patch reef and site 2 was near the crest patch reef.

#### *Selection behavior as a function of treatment and location*

To determine selection behavior as a function of treatment the two coral species were placed adjacent to each other. This gave the juvenile humbugs a choice for a preferred coral morphological structure. We had a total of 6 combination corals, 3 replicates of a combination of the two corals at each site. Having two sites allowed us to look at selection behavior as a function of location. We sampled the two sites everyday, counting the number of fish on each coral head in the morning or afternoon.

#### *Water flux at the two study sites*

In order to determine whether there was a difference in water flux through the two study sites, we used dry wall plaster to monitor its degradation over 4 days. Plaster was mixed with water in a 3:2 ratio. To slow down degradation rate of the plaster, paint was mixed into the water/plaster mixture in a 9:1 ratio. The mixture was poured into plastic cups and left to dry overnight. The cubes were 5.5 cm in diameter; 3 cm high and initially weighed 78.1 – 118.5 g. The

cubes had a piece of wire embedded in the plaster. The wire was attached to rebar adjacent to the corals at the



two sites (Fig. 3). We weighed the plaster cubes before transferring them into the water. The cubes were collected 24 and 48 hrs after they were set out. Once collected, the cubes were dried for 1.5d and weighed again to compare the total loss of plaster between sites.

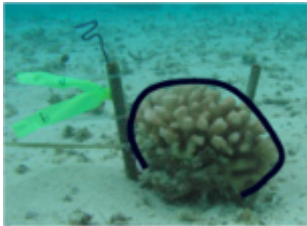
### **Figure 3.**

Plaster attached to coral head

### *Rugosity of the corals*

To take into account whether there was a difference in available shelter between *P. verrucosa* and *P. lobata*, we measured rugosity of the corals. We draped a chain over each coral to fit into all of its branches or cracks and crevices, and measured the chain length. Additionally, we estimated the length of the perimeter of the coral (Fig. 4). To get an index of rugosity for each

coral, the draped length was divided by the taut length of the chain.



**Figure 4.**

Taut length of the chain.

### *Catching fish*

All fish for our experiment were collected from the shallow lagoon at Temae on the northeastern side of Moorea. Collection took place on November 18 and 19, 2002 from 8 am to 1 pm. We found coral heads with 10-30 juvenile *D. aruanus*, put a large plastic bag over the coral head, and then took the coral head to the surface. We lifted the coral out of the bag and shook the coral over it in order to collect the fish from the coral. This was repeated until we had about 160 juvenile *D. aruanus*. The coral heads were then returned to their original location. On November

19, we stocked each coral head with 8 fish. Some of the fish died in the bag during transport or swam away upon emptying the bags over the coral heads, causing the initial densities to be 5-8 fish. Fish sizes ranged from 10mm to 25mm.

The data were analyzed using General Linear Model analysis (GLM) and ANOVA. Level of significance was  $\alpha = 0.05$ . We used Systat version 10.2.

## **Results**

### *Fidelity as a function of treatment and location*

For single coral heads at site 1 and site 2, the numbers of juvenile *D. aruanus* were higher on *P. verrucosa* than on *P. lobata* (GLM,  $df = 1$ ,  $p = 0.004$ ) (Table 1; Fig. 5). For the single coral heads *P. verrucosa* and *P. lobata*, the numbers of juvenile *D. aruanus* were not significantly different between site 1 and site 2 (GLM,  $df = 1$ ,  $p = 0.607$ ) (Table 1; Fig. 6).

### *Selection behavior as a function of treatment and location*

For the double coral heads, numbers of *D. aruanus* on *P. verrucosa* were higher than on *P. lobata* (GLM,  $df = 1$ ,  $p = 0.0005$ ) (Table 2; Fig. 7, Fig. 8). For the double coral heads, numbers of *D. aruanus* were not significantly different between site 1 and site 2 (GLM,  $df = 1$ ,  $p = 0.302$ ) (Table 2; Fig. 9).

### *Water flux at the two sites*

The loss of plaster was not significantly different between the two sites, neither on day 1 nor on day 2 (Fig. 10).

### *Rugosity*

There was no significant difference in volume between the coral heads (ANOVA,  $df = 1$ ,  $p = 0.949$ ) but the rugosity index number of *P. verrucosa* was higher than *P. lobata* (ANOVA,  $df = 1$ ,  $p < 0.00001$ ) (Table3).

## **Discussion**

### *Fidelity as a function of treatment and location*

For the single coral heads, there was a significant difference in the fidelity of juvenile humbugs as a function of treatment. Since there were more fish on the *P. verrucosa* versus *P. lobata* at both sites, we can speculate that the fish have a higher fidelity by living on *P. verrucosa*. The branching structure of *P. verrucosa* seems to provide more shelter for the humbugs to safely reside in. With high current and the presence of predators, the humbugs will be able to swim in between the branches to escape. The branches may slow down the water flow in the middle of the coral head, allowing the fish to use less energy to swim against the current and stay on the coral. The massive encrusting coral *P. lobata* seems to provide less protection from predators and high current since there is little room for the humbugs to hide. With a strong current, the water may flow faster over *P. lobata* and cause the juvenile humbugs to be forced off the coral head. Exposure off the coral head may cue in predators to attack the humbugs. It seems that a higher fidelity will occur if the humbugs settle on *P. verrucosa* because of available shelter from predators and current.

There was no significant difference in fidelity of juvenile humbugs as a function of location on the single coral heads. We expected that more fish would be present at site 1 versus site 2 because of a weaker current and less predators. The two sites may have been too close to

one another to depict a true difference in fidelity of juvenile humbugs based on various locations in the lagoon.

#### *Water flux at the two sites*

Although the plaster cubes did not show any significance in their degradation between the two sites, we did get a good indication on the strength of the water flow through the two sites. On the third day of collecting the cubes, all had been degraded at site 2 and site 1 had all the cubes intact. This indicates that the water flow was stronger at site 2 since the plaster degraded faster than at site 1.

#### *Selection behavior as a function of treatment and location*

When given a choice, juvenile *D. aruanus* showed a strong preference for branching coral, *P. verrucosa* over encrusting columnar coral, *P. lobata*. The available coral heads had similar volume, but the rugosity index was higher for *P. verrucosa* than for *P. lobata*. The branching coral possibly provides better shelter than does the encrusting, columnar coral. The result that fidelity is higher on the branching coral was in accordance with the expectation. Though the results show juvenile humbugs prefer branching coral, the pilot study indicated that *D. aruanus* were also found on *P. lobata*, but in lower abundances than on *P. verrucosa*.

Contrary to the expectation, there was no significant difference in selection behavior between the outer lagoon at site 2 and the inner lagoon at site 1. We speculated that the stronger current and possibly the presence of pelagic predators would increase selection for the branching coral at site 2. However, the results showed no effect of site on coral type choice. A possible explanation is that choice of branching coral at site 1 was close to 100% and there would be no significant difference in fidelity as a function of location.

During the daily fish counts, we observed that the bigger *D. aruanus* (app. 3-4cm) tended to swim between the two coral types, where the smaller *D. aruanus* (app. 1-2cm) tended to show a higher fidelity to one coral type. Once on *P. verrucosa*, the smaller fish did not swim to the *P. lobata*. Furthermore, no coral was stocked with more than 2 large *D. aruanus*. Yet, during the daily counts up to 3 large *D. aruanus* were recorded on the same coral head. This observation supports the speculation that larger fish are more mobile or show a lower fidelity to one coral type than do smaller fish. An improvement to this study would be to tag all stocked fish to distinguish whether bigger *D. aruanus* show lower fidelity to a specific coral type than do smaller fish.

Another concern of this study is that on certain coral heads, *D. reticulatus* and *D. flavicaudus* were recorded. A study by Schmitt and Holbrook (1999) found that *D. flavicaudus* were a superior competitor to *D. aruanus*. This may have influenced our study because corals with *D. flavicaudus* recruits might impede the fidelity in *D. aruanus* to a coral. Thus, fidelity was not necessarily a function of treatment or location, but as a function of interspecific competition. The index of rugosity was higher for the branching coral, indicating that branching corals have more available shelter per volume of coral.

Removal of *D. flavicaudus* recruits would eliminate interspecific competition with *D. aruanus*. This would be a good suggestion for a future study.

#### Acknowledgements

We want to thank Pete Raimondi, Giacomo Bernardi, Jonna Engel, Mark Readdie and Dawn Jech for their help throughout our project! The tremendous amount of time spent in the water setting up the experiment, catching fish at beautiful Temae, running the experiment, and analyzing our data forever was an amazing experience that we are glad to have been a part of. A special thanks to Dawn for helping us set up our coral heads and to Giacomo for taking us to the outside reef to

collect the corals. Thanks to Selena and Ashleigh for counting our fish one day! Guess what? Another thanks to the Biology 162 class for a great marine ecological experience in Moorea!!

## Univariate and Multivariate Repeated Measures Analysis

Between Subjects

Source	SS	df	MS	F	P
CORALSP\$	677.083	1	677.083	16.328	0.004
SITE	11.853	1	11.853	0.286	0.607
CORALSP\$*SITE	50.776	1	50.776	1.224	0.301
Error	331.744	8	41.468		

Within Subjects

	SS	df	F	P	G-G	H-F
	244.744	2	15.1	0.000	0.000	0.000
	100.000		6.2	0.000	0.008	0.001
	7.231		0.4	0.939	0.664	0.782
days*	20.641		1.2	0.242	0.305	0.297
	128.923					

Greenhouse-Geisser Epsilon: 0.1835

Huynh-Feldt Epsilon : 0.3511

### Table 1. General Linear Model analysis

Fidelity as a function of treatment (coral species) and location (site) for single heads.

Univariate and Multivariate Repeated Measures Analysis

Between Subjects

Source	SS	df	MS	F	P
CORALSP\$	920.775641	1	920.775641	31.118068	0.000523
SITE	36.0577	1	36.0577	1.218588	0.302
CORALSP\$*SITE	53.083	1	53.083	1.794	0.217
Error	236.718	8	29.590		

Within Subjects

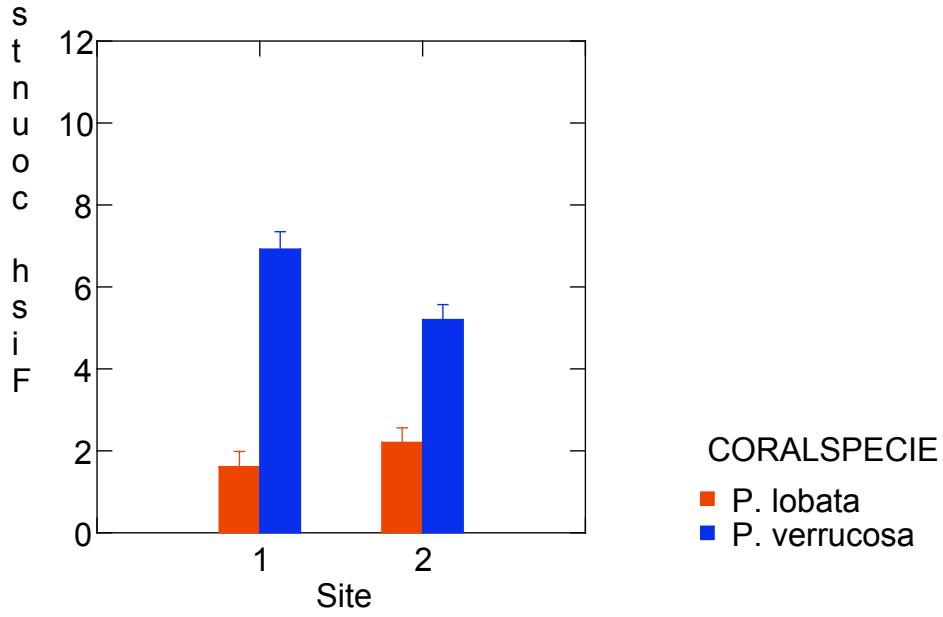
	SS	df	F	P	G-G	H-F
	11.230		0.7	0.7422	0.54776	0.64523
	41.64103	12	3.47009	2.61724	0.00461	0.02865
	1.025		0.0	1.0000	0.972	0.9988
days*	16.667		1.0	0.413	0.387	0.407
	127.282					

Greenhouse-Geisser Epsilon: 0.23028

Huynh-Feldt Epsilon : 0.49586

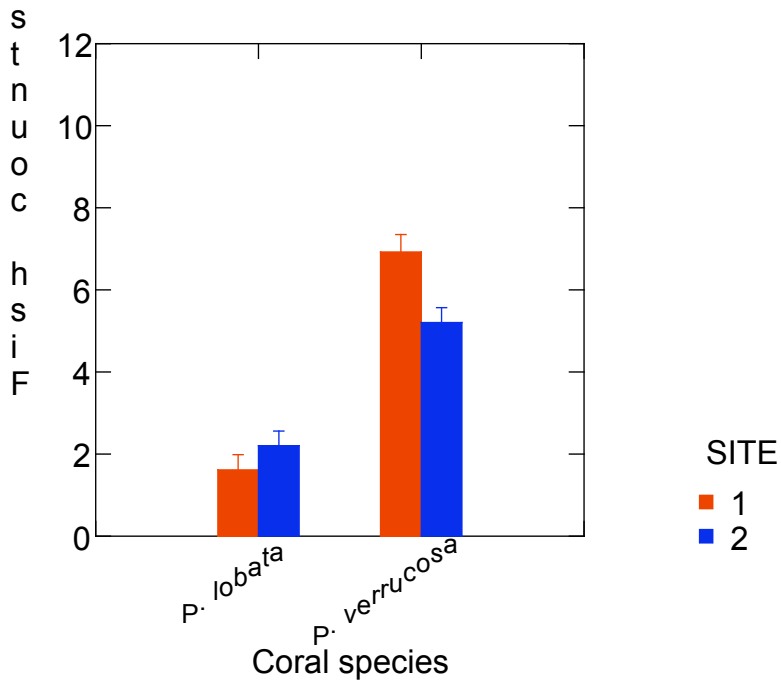
### Table 2. General Linear Model analysis

Selection Behavior as a function of coral species and location.



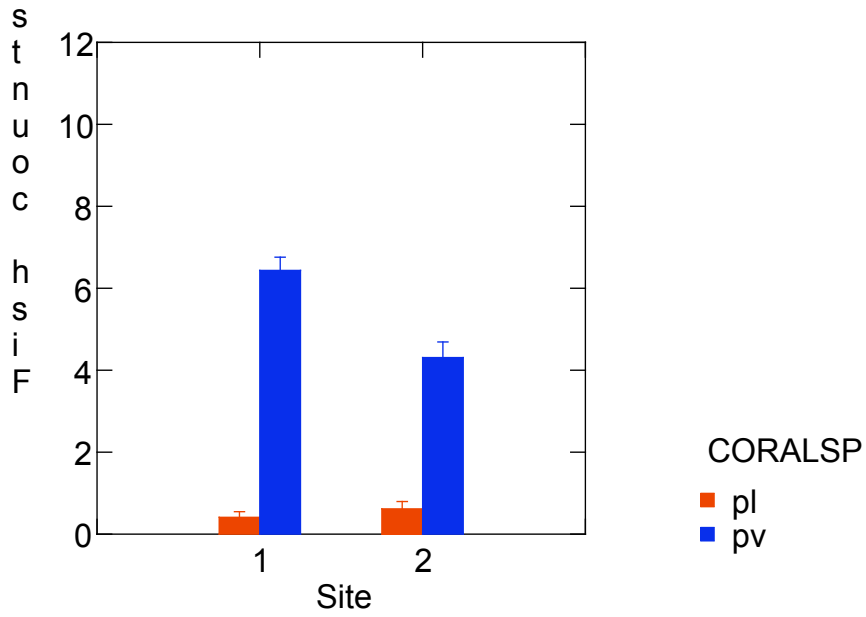
treatment.  $p = 0.004$

**Figure 5.**  
Single Coral Heads.  
Fidelity as a function of

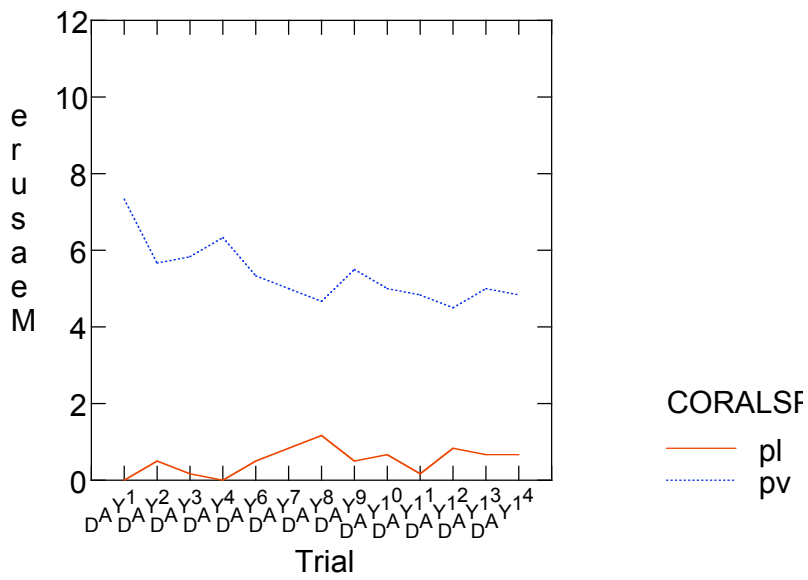


**Figure 6.**  
Single Coral Heads.

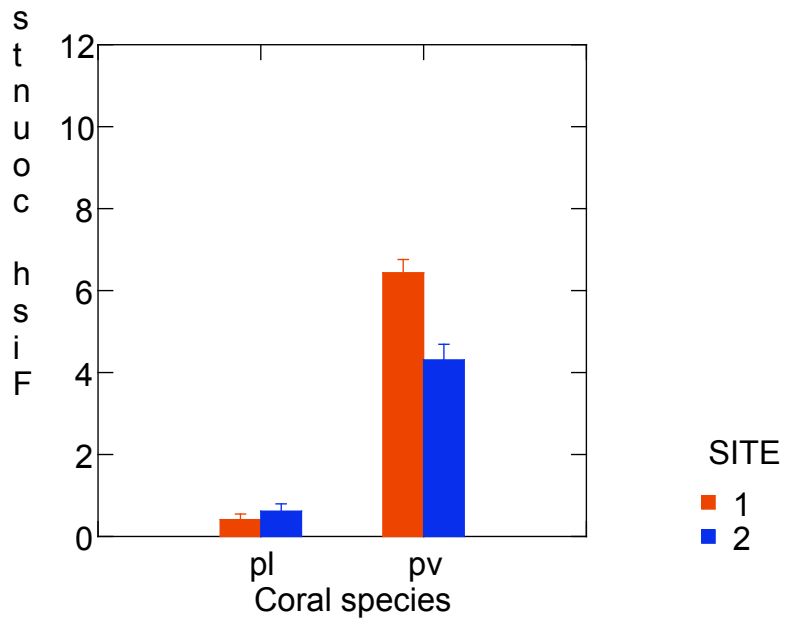
Fidelity as a function of location.  $p = 0.607$



**Figure 7.**  
Selection behavior of *D. aruanus* as a function of coral species.

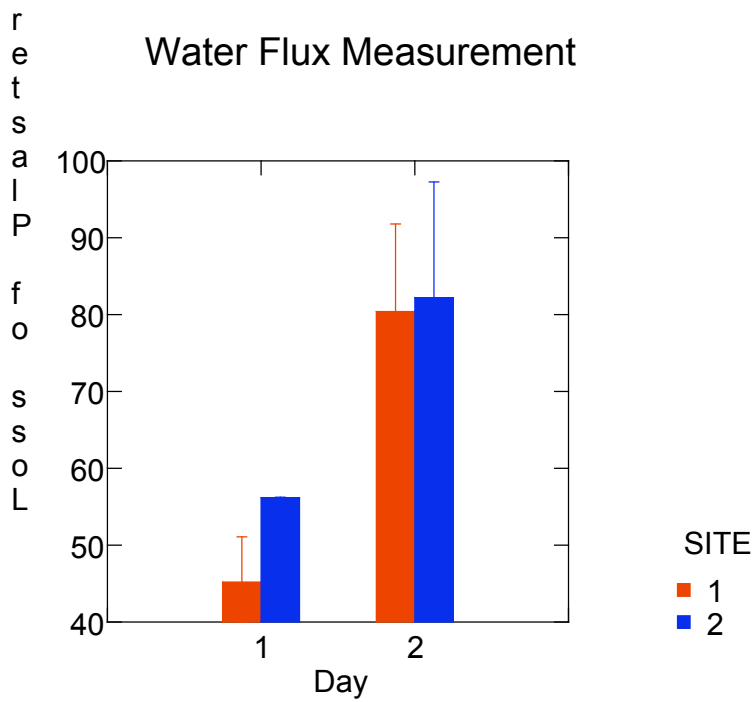


**Figure 8**  
Fish counts on double heads, at site 1 and site 2



**Figure 9.**

Selection behavior of *D. aruanus* as a function of location.



**Figure 10.**

Water flux as a function of site.

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:  
CORALSPECIE\$ (2 levels)

pl, pv

Dep Var: VOLUME N: 24 Multiple R: 0.013858 Squared multiple R: 0.000192

Analysis of Variance Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
CORALSPECIE\$	0.000000	1	0.000000	0.004226	0.948755
Error	0.000434	22	0.000020		

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Effects coding used for categorical variables in model.

Categorical values encountered during processing are:  
CORALSPECIE\$ (2 levels)

pl, pv

Dep Var: INDEXOFRG N: 24 Multiple R: 0.857274 Squared multiple R: 0.734918

Analysis of Variance Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
CORALSPECIE\$	5.041667	1	5.041667	60.993150	0.000000
Error	1.818510	22	0.082660		

**Table 3**

Rugosity and volume as a function of coral species

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