

**PROCEEDINGS
OF THE
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ON THE
NATURAL HISTORY OF THE BAHAMAS**

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Cover Photo: Dr. Lynn Margulis, Symposium Keynote Speaker, describes the structure and ecology of living stromatolites. Some, visible as grayish mounds near her feet, line the shore of Storrs Lake whereas others occur farther out in deep water. (See paper by D. C. Edwards, this volume).

Back Cover Photo: Group photo of the 6th Symposium participants and speakers.

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CLEANING SYMBIOSIS IN PUERTO RICAN CORAL REEF FISH: THE COSTS OF MUTUALISM

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ABSTRACT

Research on symbiosis between cleaner fish and their hosts has focused on the benefits gained by host fish and cleaners. Little attempt has been made to compare these benefits to quantitative measures of concomitant costs accrued by cleaners and hosts. During the summer of 1994, over 120 man-hours of observations were spent investigating cleaning stations of *Gobiosoma evelynae* on the coral reefs of southwestern Puerto Rico. We found that during cleaning events significant predation risks were incurred by host fish and perhaps cleaners as well. Fish being cleaned allowed observers to approach much more closely than when they were not being cleaned, and cleaner fish entering the mouth of piscivorous fish may be at risk of predation since results from a feeding preference study indicated that *Gobiosoma evelynae* is not distasteful to predators.

INTRODUCTION

Cleaning symbiosis in fish has been investigated extensively, but most of the work done has focused on the benefits accrued by cleaners and host fish. In tropical Atlantic coral reefs the most common cleaning fish are the neon gobies of the genus *Gobiosoma*. These are obligate cleaners whose diet consists almost entirely of gnathiid isopod larvae (Randall 1967). Many authors have attempted to document the beneficial effect of parasite removal on host fish visiting cleaning stations (Limbaugh 1961; Hobson 1971; Losey 1974; Gorlick et al. 1987; Slobodkin & Fishelson 1974).

Very little work has been done to document further subtleties of the relationship

between cleaner fish and their hosts, and almost nothing has been published on possible costs resulting from this symbiosis (but see Gorlick 1980). Trivers (1971), discussing cleaning symbiosis as a possible case of reciprocal altruism, suggested that two significant costs may be involved in this apparent mutualism. First, he suggested that host fish refrain from eating the cleaners which would be an easy and adequate food item. Second, he suggested that host fish make themselves more prone to predation by postponing escape responses until cleaner fish leave. Trivers suggestions were criticized by Gorlick et al. (1978). Rather than interpreting host behavior as a form of altruistic restraint, they suggested that cleaner fish behavior may explain their immunity from predation. Specifically, they suggested that cleaner fish may avoid predation from their hosts by avoiding the mouths of piscivorous fish and they may be distasteful to predators (Colin 1975).

In this paper I document work done to investigate the possible costs to cleaners and host fish in cleaning symbiosis on Puerto Rican coral reefs. The first experiment compares escape responses of fish being cleaned to that of fish away from cleaning stations to test the hypothesis that being cleaned imposes real predation risks. The second experiment investigates the claim of Gorlick et al. (1978) that cleaning gobies are distasteful to predators. The results of these experiments suggest that cleaning symbiosis, while producing obvious benefits to cleaner and host, also carries significant costs which must also be considered to fully understand the evolution of this remarkable relationship.

METHODS

During June, 1994, two field assistants and I, using SCUBA gear and plastic slates for recording data, logged more than 120 man-hours of bottom time investigating cleaning stations of the shark-nose goby, *Gobiosoma evelynae*, on the coral reefs of Southwestern Puerto Rico near the town of La Parguera. All observations were made between 0800-1200 hrs. Two experiments were completed. The first investigated the possible predation risks to fish visiting the cleaning stations to be cleaned. The second tested the suggestion of Gorlick et al. (1978) that cleaner gobies are distasteful to predators.

Host Fish Escape Response

To measure possible predation risk, cleaning stations were observed until a fish began to be cleaned by gobies. At that time, an observer would approach the host fish with a slow swimming motion pointing with a hand held spear from a spear gun. The spear was marked in 10 cm sections and was used as a measuring stick to estimate the distance between the tip of the spear and the fish at the time of its escape. As a control, another individual of the same species was then located away from a cleaning station. The same technique was used with this individual to measure escape distance. These measures were taken throughout the month of June at various reefs.

Palatability of *Gobiosoma evelynae*

To determine whether or not *G. evelynae* is distasteful to predators, a field experiment was done at Mario Reef at a depth of approximately 3 m. Mario Reef has many scattered heads of *Montastrea annularis* which house yellowtail hamlet territories. Yellowtail hamlets are small piscivorous serranids, and because of their willingness to approach a diver (they are too small to be targets for spear fishermen) they were chosen as the subjects for a feeding experiment to compare the palatability of *G. evelynae* and a control fish that is known to be edible. The control fish chosen was a sardine (*Jenkinsia* sp.). These fish are easily caught around docks, are known

to be eaten by a large number of fish (Randall 1967), and are similar in size to *G. evelynae*.

On June 25, 14 gobies were collected at Mario Reef. Due to their unwillingness to move off of the coral into the water column, it was fairly easy for two divers to chase them into a plastic bag held close to the surface of the coral. These fish were transported alive to the lab where they were measured, pithed to minimize suffering, gutted, placed individually in small screw-cap vials, then frozen. The internal organs were removed for subsequent stomach analysis and to render the fish negatively buoyant. Fourteen *Jenkinsia* were collected with dip nets on June 27 and processed in the same way.

On June 28 I took the vials containing the fish to Mario Reef and the fish were allowed to thaw. Using SCUBA I would find a yellowtail hamlet, kneel on the sand near the hamlet, then open a vial and drop one of the dead fish (either a goby or a sardine) in front of the hamlet. I recorded whether or not the fish was eaten, the number of handling events before ingestion, and other behavioral observations. I then repeated this procedure with the other type of fish. The order of presentation (goby first or sardine first) was determined by coin flip before the start of the experiment. A hamlet was used for only one pair of presentations, so a total of 14 hamlets was used as subjects.

RESULTS

Host Fish Escape Response

During the course of this experiment, 88 escape responses were measured for a total of 27 species of fish at cleaning stations. We were able to find suitable controls (i.e., different individuals of the same species at the same reef and at the same time) for 61 of these.

Although escape distances differed between species, a paired t-test allowed us to combine all species to assess differences between escape responses of fish on cleaning stations and those away from cleaning stations (Figure 1). Fish that were cleaning allowed us to approach much more closely than those away from cleaning stations (paired t-test, $df=60$, $t=5.453$, $P < 0.001$). Indeed, on some

occasions fish at the cleaning stations actually allowed physical contact with the spearpoint before escaping.

Palatability of *Gobiosoma evelynae*

In all fourteen trials of the palatability study, both the sardine and the cleaning goby were eaten by the yellowtail hamlets. In no case were the gobies rejected or regurgitated. Figure 2 shows that the mean handling events

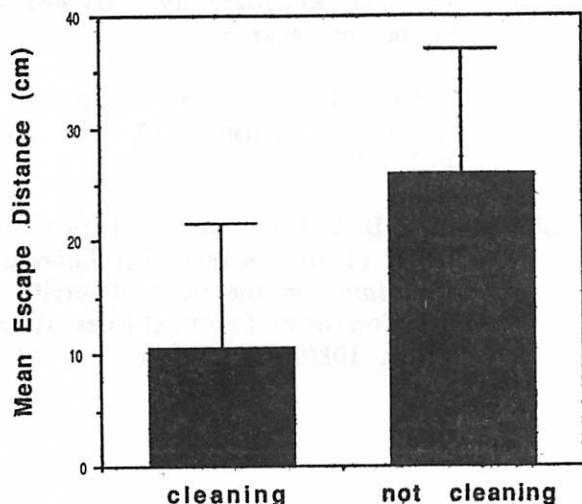


Figure 1. Mean escape distance of fish at cleaning stations as compared to conspecifics away from cleaning stations. (n=61, bars indicate 1 s.d.)

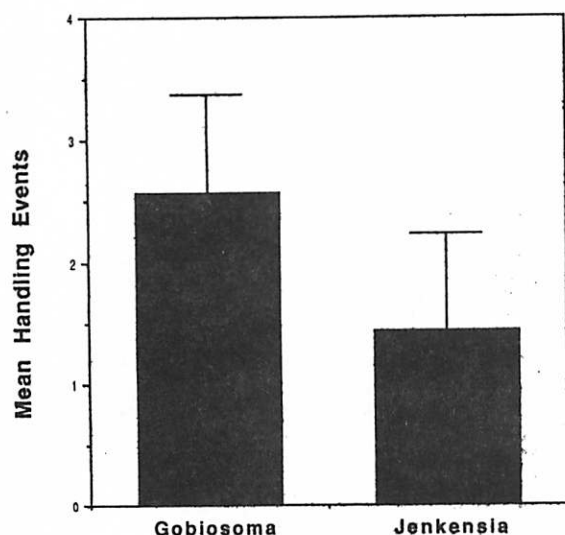


Figure 2. Mean handling events (nips, carries, gulps) required to ingest dead test fish by yellowtail hamlets. (n=14, bars indicate 1 s.d.)

(including nips, carries, and gulps) were fewer for the sardines than the gobies, but this is readily explained by the larger size of the gobies (*Gobiosoma evelynae* length = 29.7 ± 3.6 mm ($\bar{X} \pm$ s.d.) vs. *Jenkinsia* sp. length = 20.9 ± 1.5 mm). The relationship between prey size and handling difficulty was demonstrated in one trial in which a small yellowtail hamlet repeatedly tried unsuccessfully to eat a very large goby. When the goby was broken into two, it was quickly consumed with minimal effort.

DISCUSSION

I have shown that fish visiting cleaning stations allowed divers with spears to approach much more closely than when the fish were away from cleaning stations. Assuming that divers are good models of predators (and in heavily populated and overfished Puerto Rico, this would seem a valid assumption), this supports the hypothesis that fish visiting cleaning stations for ectoparasite removal expose themselves to a significant risk of predation. Since over 50 species of fish have been shown to visit cleaning stations on Puerto Rican coral reefs (DeLisle 1969), and since many individuals spend considerable time there, this suggests that the benefits of cleaning (and conversely the costs of parasitism) must be staggering.

The palatability study clearly falsifies the hypothesis of Gorlick et al. (1978) that cleaner gobies avoid being eaten by piscivorous host fish due to their unpalatability. Recently killed *Gobiosoma evelynae* are readily eaten by yellowtail hamlets. Not only does this demonstrate their palatability, it also demonstrates the importance of cleaner fish behavior for inhibiting the feeding behavior of host fish (see also DeLisle 1969).

Collectively, these results lend support to Trivers' suggestion that cleaning symbiosis may have evolved via reciprocal altruism (Trivers 1971). Host fish refrain from eating acceptable prey and risk predation while at cleaning stations. Furthermore, cleaner gobies risk predation to clean host fish. It is not uncommon to see *G. evelynae* cleaning in the mouths of some fish, and in our study these were always larger piscivores and thus potential predators.

In any case, it is clear that some mutualisms may be much more than a simple sharing of benefits between symbiotic partners.

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**ERRATUM FOR THE PROCEEDINGS OF THE 6TH SYMPOSIUM ON THE NATURAL
HISTORY OF THE BAHAMAS VOLUME**

- p. 97; The authors of the paper titled **CLEANING SYMBIOSIS IN PUERTO RICAN CORAL REEF FISH: THE COSTS OF MUTUALISM** should read:

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- p. 98; 1st sentence of Methods should read: During June 1994, using SCUBA gear and plastic slates for recording data, we logged more than 120 man-hours of bottom time investigating cleaning stations of the shark-nose goby, Gobiosoma evelynae, on the coral reefs of Southwestern Puerto Rico near the town of La Parguera.
- p. 98; last paragraph of Methods section: Change all "I"s to "We".
- p. 99; first sentence of Discussion: Change "I" to "We".
- p.100; acknowledgements, the entire section should read: We would like to thank Warren Wilson College and Burroughs Wellcome Foundation for sabbatical assistance to Paul Bartels.