Natural illumination effects on the habitat choice of the fish *Pseudochromis fridmani*

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1 Introduction

The orchid dottyback, *Pseudochromis fridmani*, is a fish of about six centimeters endemic of the Red Sea and abundant at Mangrove Bay (near Al Quisir, Egypt). *P.fridmani*'s coloration differs relative to illumination conditions. Its scales present both red and blue pigments, and the entire body behaves as translucent for red light. In its natural environment -vertical walls of coral reefs- the fish appears as a blurry purplish patch.

Red and blue light lay at both extremes of the color spectrum. In the human retina, such wavelength disparity translates into different focal depths for the same crystalline lens contraction, resulting into blurriness of objects that contain a mixture of exclusively blue and red, like the orchid dottyback. Such blurriness effect may have been exploited by the fish as a predator escape mechanism.

The depth distribution of the orchid dottyback spans from 0.5 to 20 meters, a range within which acute differences of red and blue light occur. Light wavelength correlates with light energy, which affects the penetration capabilities of light into water. Red light, of higher wavelength and thus lower frequency and lower energy than blue, is absorbed at much shallower waters than blue light. In addition, from sunrise to sunset light conditions in the reef change, not only in cardinal light source orientation but also in quality, namely in intensity and wavelength composition.

This work focuses on the habitat choice of *P. fridmani* relative to light conditions. In particular, the question of habitat preference relative to depth -and thus red light absorption-, and relative to the sun's position in the sky.

2 Methods

2.1 Reef exploration

The coral reef was explored by means of iterative snorkeling and scuba diving sessions. Each session concentrated on a specific area, delimited by easily identifiable landmarks, to avoid unintentional sample replication. Areas with a depth requiring scuba diving sessions were sampled only twice and at significantly separated hours of the day, like early morning and mid afternoon. Areas on shallow waters within snorkeling reach were sampled numerous times.

2.2 Habitat observation, data collection sequence and parameters

On identification of *P. fridmani* individuals, their immediate environment -the habitat- was observed for at least 10 seconds. When snorkeling, each site was observed over several duck dives; when scuba diving, each site was observed for roughly 20 seconds.

On starting each session, the time of the day was noted, indicative of the sun's position in the sky. For each site, several parameters were measured. First, the overall habitat's environment was observed at a glance, including the presence or absence of a roof and lateral walls. Second, the approximate cardinal orientation of the main opening of the habitat, i.e. the direction towards north, east, etc. of an imaginary line perpendicular to the main reef wall of the habitat. Third, after all commotion of the observer's presence faded, the number of fish was counted, and their dimensions noted, in a gross scale of large or small. Any particulars of the specific habitat were also noted, including proximity to larger fishes, presence of other fishes within the habitat, presence of water currents, and others.

2.3 Data processing

Data collected within a sampling session was split into roofed and unroofed habitats. Then, the percentage of data points was obtained for each cardinal orientation (north, northeast, etc.). When the sample was large enough, each sampling point was weighted by the number of fishes it contained, which resulted in sharper results for sampling site 4. Finally, habitat orientation percentages were plotted over a compass scheme.

3 Results

Four different sampling sites were selected to encompass a variety of environmental parameters such as bay or open waters, and depth (fig. 1). Only site 4 was sampled twice at significantly different time points of the day. At each sampling site, the orientation of a line perpendicular to the main reef wall of the fishes habitat was recorded, along with the number of fishes and the depth.

Two sampling sessions were performed at site 4 at depths between 8 and 14 meters (fig. 2). In the early morning, from 62 fish habitat identifications, 13 were roofed and 49 unroofed, and 29 of

57 contained a single individual. In the late afternoon, a shorter sampling session on the same area produced 4 roofed and 14 unroofed habitat identifications, with 5 of 18 with a single individual.

The orientation of the habitat's main wall did not change from morning to afternoon for roofed habitats, but unroofed habitats show a dramatic change from northeast to southeast (fig. 2). The data suggests that *P. fridmani* individuals actively move around the reef blocks during the day, keeping the reef block wall between themselves and the sun.

When not weighted by fish numbers, the orientation preference is not as sharp; sites with a single fish show less orientation preference than sites with multiple fishes (data not shown).

Sites 1, 2 and 3 were not sampled at different time points along the day as site 4 was, for the researcher was unaware of potential differences between morning and afternoon.

Site 1 and 3 contain low depth data points and consist mostly of roofed habitats (34 out of 35), suggesting that *P. fridmani* prefers roofed habitats at low depth. All observed roofed habitats were totally on the shade.

Site 2, on the outer reef, contains zero data points at snorkeling depth and only 6 data points between 9 to 14 meters, despite extensive sampling. Uncontrolled factors such as water currents may explain why so few *P. fridmani* can be found on the outer reef.

Only 6 from a total of 121 observed habitats presented direct sun rays on the fishes, strongly indicating a preference for shaded areas. On the shade, the blurriness effect is stressed.

4 Discussion

At Mangrove's Bay latitude in October, the sun describes a trajectory from east-south-east to west-south-west, creating a changing continuum of light source orientation from sunrise to sunset.

In shallow waters (1-4 meters), nearly all sites (34/35) are roofed, indicating that direct light is too strong for *P. fridmani*'s preference. In deeper waters (7-14 meters), where a significant amount of red light has been already absorbed, unroofed habitats prevail, and habitat orientation preference shifts during the day keeping the reef wall between the fishes and the sun.

When *P. fridmani* can be found, individuals choose both roofed and unroofed habitats. The fact that roofed habitats do not change noticeably in orientation during the day, despite being distributed among those unroofed, which do, suggests that uncontrolled factors such as changing water currents do not play a role in *P. fridmani*'s habitat orientation choice.

The ability of *P. fridmani*'s body to transmit red light, and to appear as blurred at the observer's eyes when combined with blue light illumination, lead Nico Michiels to formulate the hypothesis that the fishes may look for sources of red light to place behind themselves in absence of sufficient ambient red light, such as at depths beyond 7 meters. In no sampled site were red light sources -such as red corals or algae- detected within the fishes habitat. Such hypothesis is not supported by hereby reported observations.

Remarkably, in shallow waters (less than 4 meters), nearly all *P. fridmani* show a preference for roofed, shaded sites. Only at higher depths are *P. fridmani* individuals found dwelling by unroofed reef walls in abundant numbers.

5 Remarks

The experimental method changed throughout the span of the sampling sessions, and a proper method became clear only over the last sampling sessions; therefore site 4, explored the latest, is much better sampled than any other.

Future work should schedule sampling sessions at different time points of the day. In addition, specific reef blocks containing clearly distinguishable groups of *P .fridmani* should be marked for reliable observation of orientation preference rotations along the day.

6 Acknowledgments

The author is indebted to Nico Michiels and Gregor Schulte for sharing plenty of information on *P.fridmani*'s coloration resulting from their experimental observations in the laboratory. And for a great trip to Mangrove Bay!

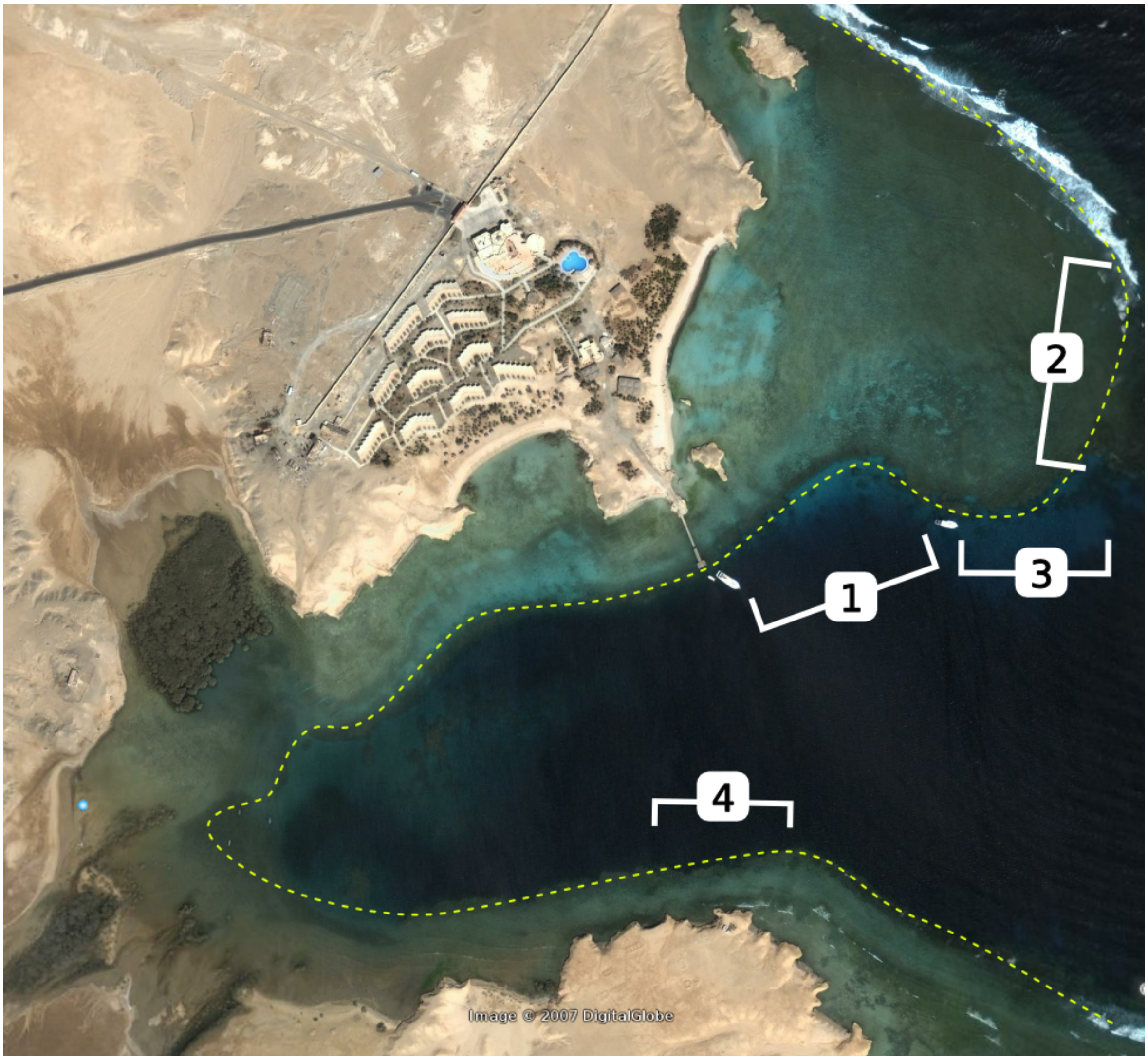

Figure 1: Map of Mangrove Bay, Red Sea, Egypt, depicting the rough limits of the reefs (*dashed line*) and of the 4 sampling sites. Only site *2* faces the open sea. North is up. Image from DigitalGlobe, GoogleEarth.

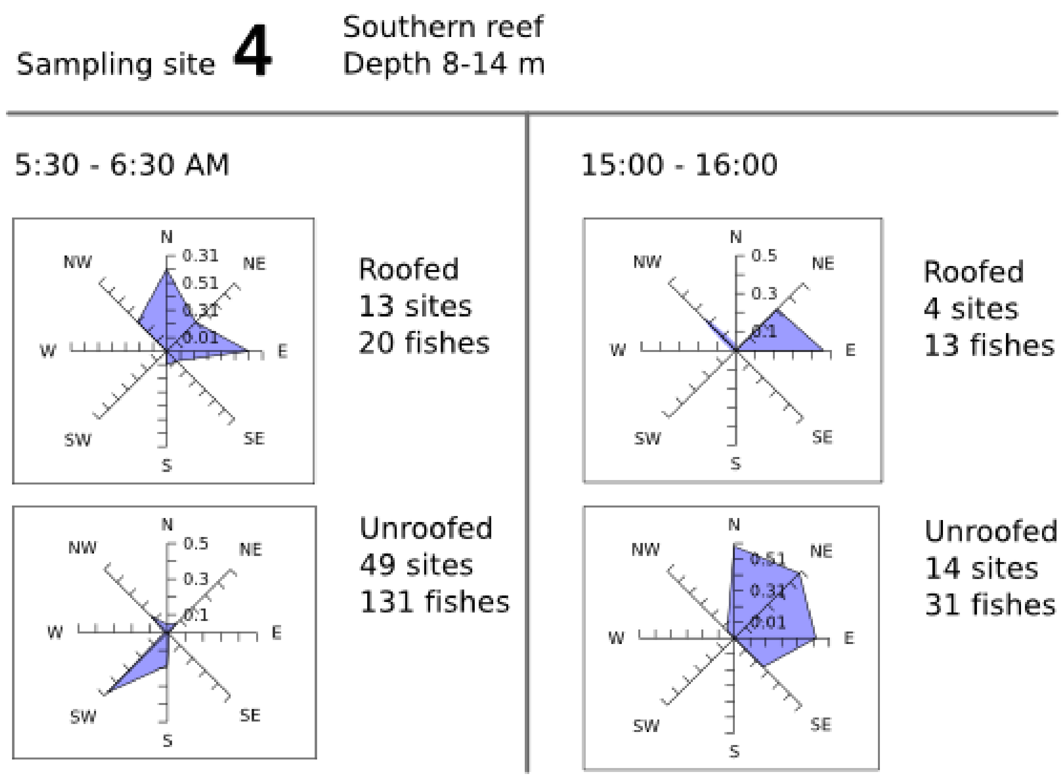

Figure 2: Sampling site 4, southern reef. Plotted are the habitat main cardinal orientation at early morning (*left*) and late afternoon (*right*), split into roofed and unroofed, and weighted by the number of fishes in each site. Sampling dates: 9th and 7th of October (2007) respectively. While the orientation of roofed habitats remains unchanged (*top panels*), that of unroofed sites changes dramatically from southwest to northeast: fishes keep the reef wall between themselves and the sun throughout the day. The data suggests strong light orientation preference of *P. fridmani*.

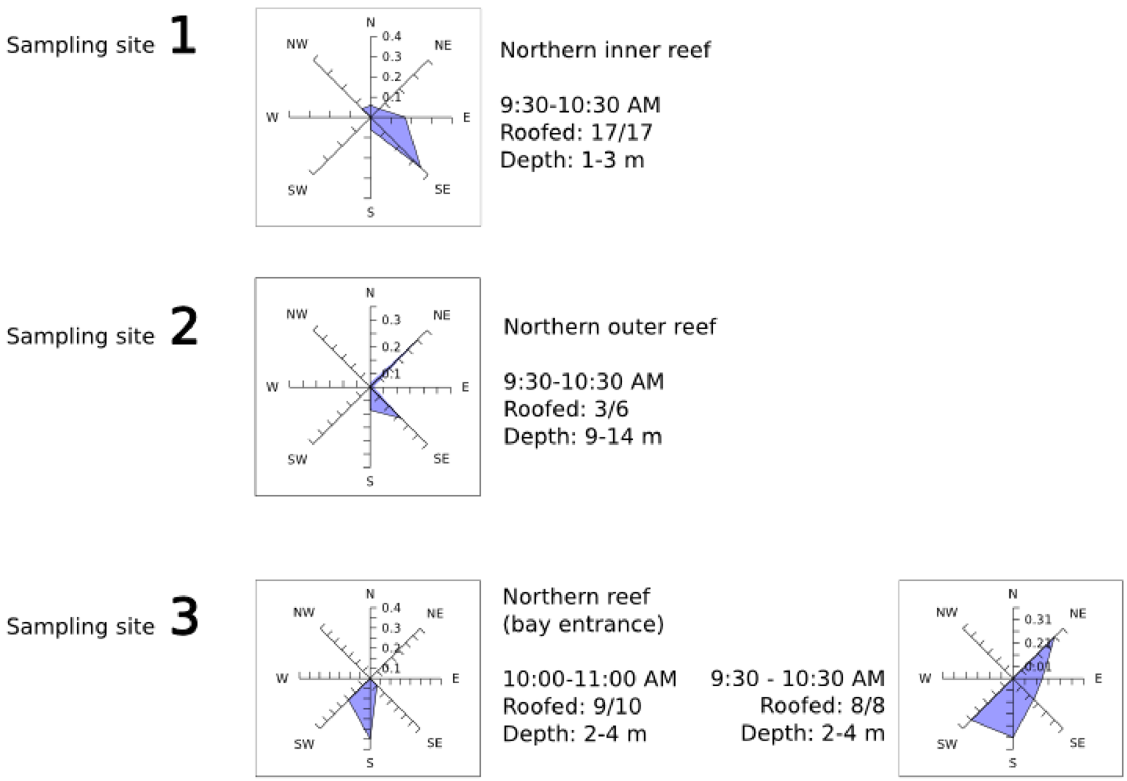

Figure 3: Sampling sites 1 (northern inner reef), 2 (northern outer reef) and 3 (northern reef entrance; two samples). Plotted are the habitat main cardinal orientation. No distinction is made between roofed and unroofed sites, since at shallow waters (2-4 meters) nearly all sites are roofed (34/35) and sample size is not large enough for sample site 2.