FISH DIVERSITY ON A CORAL REEF IN THE VIRGIN ISLANDS

by Michael J. Risk[1]

INTRODUCTION

Terrestrial ecologists have accumulated data relating bird species diversity to foliage height diversity (MacArthur and MacArthur, 1961; MacArthur, 1964; Recher, 1969); complexity of foliage pattern seems to be a better predictor of bird species diversity than is the tree species diversity. There is some indication that a similar relationship exists on coral reefs, between fish species diversity and substrate complexity. Talbot (1965, p. 453), in comparing fish collections from areas with either few or many species of corals present, states "It is probable that the greater variety of coral species...allows for a more varied fish population than the single species," and, "It is probable that the more complex coral population in the mixed stand provides more ecological niches than are available in the single species stand." Hiatt and Strasburg (1960, p. 118) found more species and individuals on "ramose" than on "glomerate" coral heads: "Because glomerate coral heads are generally devoid of interstices in which small organisms can hide, such heads are visited only by fish species intent on browsing or grazing coral polyps." In a study on *Conus*, Kohn (1967, p. 257) found "Type III habitats are topographically the most complex...and these support the most diverse assemblages of *Conus*." The author attempted to measure the relationship between fish species diversity and the physical makeup of the coral substrate, following the work done on bird species diversity.

PROCEDURE

(a) *Study area*

The area selected was a portion of a low-lying, shallow patch reef located in the eastern part of Greater Lameshur Bay, St. John, Virgin Islands. Substrate types within the area were live coral *(Montastrea annularis, Millepora alcicornis, Porites furcata,* and *Agaricia agaricites),* dead coral, sponges (mostly *Ircinia* spp.) and carbonate sand.

(b) *Sample locations*

Two transects were laid out in the form of a "T", with the upright perpendicular to the shore, and the crosspiece further offshore and parallel to the shoreline.

The "upright" transect began about 50 meters from shore, in 4 meters of water, and extended 16 meters seaward, to a depth of 4.5 meters. The "crosspiece" transect was also 16 meters long, and 4.5 meters deep throughout its length.

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[1]Department of Biological Sciences, University of Southern California,
Los Angeles, California 90007

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(c) *Determination of fish species diversity, "Hf"*

Only territorial fishes were considered in this study. Several days were spent diving and observing in the area, in order to determine which species were territorial. When doubt existed about a particular fish, it was frightened into its home territory several times over the course of 2 or 3 days. Only fishes consistently returning to the same location were counted; appropriate members were three species of damselfish, a goby, a squirrelfish, and occasional filefishes, tangs, juvenile grunts and snappers. All caves, crevices, and holes were investigated, often using a light.

Numbers of individuals of the selected species were then determined in each of the sixteen quadrats. Each area was counted at least twice a day for a period of three days. To reduce operator bias, previous values recorded on underwater slates were left on shore, and the quadrats counted beginning at different ends of the two transects (see Appendix A).

Census values were in good agreement, and ranged from 4 to 7 species and from 7 to 21 individuals per square meter. Fish species diversity values were calculated using Shannon's formula for H' (Shannon, 1948).

(d) *Determination of substrate topographic complexity, "T"*

Actual surface area of a substrate as compared to its horizontal projection area was assumed to be a measure of spatial heterogeneity. The technique used was a modification of geological "point-counting," wherein volumes of constituents are assumed proportional to their representation along line transects. In the present study, actual surface area was assumed to be a function of actual linear dimensions.

The author used a fine-link chain, which could be draped and applied over a length of one meter. This was done eight times for each meter-square quadrat; in some cases four meters of chain were required to equal one "straight" meter.

Actual surface area was assumed proportional to the squares of these estimates of actual linear dimensions; therefore, the value of T for any one quadrat is the sum of the eight estimates, squared. These values are recorded in Appendix B.

(e) *Determination of substrate biological diversity "B"*

The substrate was arbitrarily divided into seven constituents: four species of living coral, dead coral, sponges, and carbonate sand. Different species of living coral were almost always separated by a band of dead coral; sponges grew only on this dead coral.

Each constituent type was assumed to have areal coverage proportional to its intersect length along line transects. Again, in each of the sixteen quadrats, intersect length were determined along eight one-meter line transects. The result for each quadrat was therefore a total length of eight meters, divided among up to seven constituents.

B was then calculated from these data, using Shannon's formula for H'; values for each quadrat are recorded in Appendix C.

(f) *Data processing*

Multiple regression analysis was performed on the data at the University of Southern California Computer Sciences Laboratory.

(g) *Underwater data gathering*

The author is familiar with data-gathering by SCUBA, having conducted benthic surveys and studies in a variety of non-tropical habitats. The amount of time and energy required to measure only sixteen sample areas was staggering.

For this study, the author spent 80 hours underwater; including the preliminary study, more than 800 fishes were identified, and their territories noted; intersect values for substrate types were determined (to the nearest millimeter) along 144 meters of reef, and 1,028 meters of chain were stretched over the reef surface. To measure each meter-square quadrat took at least five hours.

RESULTS

Significant relationships between the three main variables (H_f, T and B) were tested for. In addition, many subdivisions of the main variables, such as sand cover, total coral cover (live or dead), and total fishes, were investigated.

Significant correlation exists only between fish species diversity, H_f, and substrate topographic complexity, T. Results of analysis of the three main variables are given in Table 1.

Table 1. CORRELATION COEFFICIENT MATRIX

	H_f	T	B
H_f	1.000	*0.624	0.004
T	-	1.000	-0.161
B	-	-	1.000

*$p < 0.05$

Regression Equation: $H_f = 1.06 + 0.004T + 0.108B$

Multiple correlation coefficient 0.633.

H_f = fish species diversity ("nits")
T = substrate topographic complexity
B = substrate biological diversity

The regression coefficient for T is highly significant ($p < 0.01$); that for B is not significant. Increase in the multiple correlation coefficient on addition of the B effects to those of T is only 0.009.

DISCUSSION

Although the number of samples is quite small, there exists a striking positive correlation between fish species diversity and degree of substrate topographic complexity. This result is in accordance with predictions from terrestrial bird studies.

It is interesting that there is no significant correlation between fish species diversity and the biological nature of the substrate; the choice of a territory would seem to be controlled by predation pressure, rather than by feeding preferences.

There is also no significant positive correlation between total numbers of fishes and either substrate topographic complexity or substrate biological diversity; the relationship does not appear to be a simple one of "more holes, more fish." There apparently is occurring some selective partitioning of the habitat by individual fish species.

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APPENDIX A

POPULATIONS OF TERRITORIAL FISHES IN SAMPLE AREA

Transect No. 1 (Perpendicular to shore)

Quadrat No.	*Eupomacentrus fuscus*	*Eupomacentrus planifrons*	*Microspathodon chrysurus*	*Gnatholepis thompsoni*	*Lutjanus* sp. (juv.)	*Haemulon sciurus*	*Holocentrus rufus*	*Acanthurus coerulens*	*Monacanthus tucheri*	*Hypoplectrus puella*	Total No. of fishes
1 (shallow)	4	3	2	3	1	2	-	-	-	-	15
2	3	3	1	3	-	-	-	-	2	-	11
3	2	1	1	3	-	-	-	-	-	-	7
4	4	2	3	1	-	1	1	-	-	-	12
5	3	1	1	1	1	3	2	-	-	-	12
6	5	1	1	2	-	-	2	-	-	-	11
7	3	1	-	2	1	-	2	-	-	-	9
8 (deep)	2	3	1	-	-	-	6	-	-	-	12

Transect No. 2 (Parallel to shore)

Quadrat No.	*Eupomacentrus fuscus*	*Eupomacentrus planifrons*	*Microspathodon chrysurus*	*Gnatholepis thompsoni*	*Lutjanus* sp. (juv.)	*Haemulon sciurus*	*Holocentrus rufus*	*Acanthurus coerulens*	*Monacanthus tucheri*	*Hypoplectrus puella*	Total No. of fishes
1 (north)	2	3	1	6	-	-	-	1	-	-	13
2	3	1	2	4	1	-	-	1	-	-	12
3	3	2	1	6	-	-	-	-	-	1	13
4	3	2	1	5	1	-	-	-	-	-	12
5	5	2	-	3	-	-	-	1	-	-	11
6	7	4	4	4	-	-	-	2	-	-	21
7	3	4	1	4	-	-	-	-	-	-	12
8 (south)	2	3	5	8	-	-	-	-	-	1	19

APPENDIX B

VALUES OF T, SUBSTRATE TOPOGRAPHIC COMPLEXITY (m^2)

Transect No. 1

Quadrat No.	T
1 (shallow)	75.5
2	95.7
3	28.2
4	97.2
5	85.8
6	97.1
7	103.1
8 (deep)	37.2

Transect No. 2

Quadrat No.	T
1 (north)	36.5
2	73.6
3	21.3
4	44.2
5	35.4
6	84.1
7	53.7
8 (south)	60.0

APPENDIX C

VALUE OF B, SUBSTRATE BIOLOGICAL DIVERSITY ("nits")

Transect No. 1

Quadrat No.	B
1 (shallow)	1.34
2	1.23
3	1.17
4	1.12
5	1.34
6	0.98
7	1.11
8 (deep)	1.17

Transect No. 2

Quadrat No.	B
1 (north)	1.21
2	1.40
3	1.06
4	1.34
5	1.43
6	1.23
7	1.68
8 (south)	1.08