

Biogeography of Coral Reef Shore Gastropods in the Philippines

Thesis submitted by

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ABSTRACT

The aim of this thesis is to describe the distribution of coral reef and shore gastropods in the Philippines, using the species rich taxa, *Nerita*, *Clypeomorus*, Muricidae, Littorinidae, *Conus* and *Oliva*. These taxa represent the major gastropod groups in the intertidal and shallow water ecosystems of the Philippines. This distribution is described with reference to the McManus (1985) basin isolation hypothesis of species diversity in Southeast Asia. I examine species-area relationships, range sizes and shapes, major ecological factors that may affect these relationships and ranges, and a phylogeny of one taxon.

Range shape and orientation is largely determined by geography. Large ranges are typical of mid-intertidal herbivorous species. Triangular shaped or narrow ranges are typical of carnivorous taxa. Narrow, overlapping distributions are more common in the central Philippines.

The frequency of range sizes in the Philippines has the right skew typical of tropical high diversity systems. This shows that there are many species with small range sizes, and suggests a tendency for these ranges to overlap.

The species area curves are consistent with predictions of basin isolation on species richness. The central Philippine basins (Visayas and, Sibuyan) have a z estimate (a parameter of the Species Area relationship or SPAR) close to unity (0.59-1.30). This contributes to biogeographical provinciality (a measure of faunal uniqueness) in these basins. The basin that is most provincial is the Sibuyan Sea basin. However this provinciality may also be due to a small-area effect or the decoupling of species richness with area as a result of habitat heterogeneity within the basin. Endemicity of taxa is observed mainly in the central, as opposed to the peripheral, oceanic basins.

A regression approach was applied to test the effects of larval duration and habitat availability on range size and species richness of *Conus*. The results suggest that habitat is a more significant factor in determining species ranges and species richness than larval duration. This supports the suggestion from basin isolation for an important effect

of habitat heterogeneity on range size and species richness. . Extinction rate estimates are negative for the Philippines and other areas in the Indo-West pacific (IWP). This suggests that species in the Philippine basins, and the IWP in general, have been accumulating in these areas over the past 18,000 years.

In *Conus*, the mode of speciation was inferred from a published molecular phylogeny, coupled with data on modern ranges. This study also tried to infer *Conus* speciation within the IWP. The relationship of modern ranges and phylogenetic information is not informative, and does not provide inferences on the mode or location of speciation. The ranges and phylogenetic patterns of *Conus* suggest that changes in range extents have been large during the evolution of the genus. This may be due to the long larval duration, that allows for wide dispersal, being largely conserved during *Conus* evolution.

In the sand-dwelling coral reef genus *Oliva*, the ranges and species area curves were similar to those of *Conus*. The central Philippines basin of the Sibuyan Sea has the highest degree of provinciality. The area of the OGU (geographical regions) affects species richness of *Oliva* significantly. This observation is consistent with results of a PCA ordination of the frequency of occurrence of *Oliva*. The presence of sandy habitats affect *Oliva* species richness significantly. The morphological diversity of two widely distributed species of *Oliva* was studied. Monotopic species (species that are found only in a single substrate type) tend to show morphologies that are found only in certain oceanic basins.

Modern ranges suggest basin isolation as an historical process that has maintained and possibly caused the high taxonomic diversity of intertidal and shallow water gastropods in the IWP. There is evidence that high species diversity in IWP is likely related to the existence of numerous habitats. The geological histories of the Philippine oceanic basins may provide important information in future biogeographic studies of patterns of species richness. The evidence is considered with respect to current molecular phylogenetic studies of gastropods. The study highlights the paradox of low endemism in a highly diverse region. Suggestions are made for future research that could provide insight into the nature of endemism and species persistence of marine organisms in the IWP.

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Back in High School and until now, my favourite scientists have always been Galileo Galilei, Albert Einstein and John Steinbeck. You may wonder why John Steinbeck is in the list. While Galileo is rightly known to be the first modern scientist and Einstein flunked his PhD exams twice, Steinbeck is better known as a Nobel Prize winning writer. Steinbeck has only one science publication under his name and this was written with another marine biologist, Ed Ricketts. Steinbeck clearly understood that the impulse to do science and to find meaning in all things is the same.

Nevertheless, Galileo, Einstein, Steinbeck, Ricketts and all the other good scientists did was to take that “bold guess” to conjecture and daringly propose explanations to the inner realities of what the world was all about. While we are unlikely to be that bold in the sense of Karl Popper, I hope that we can try to be like Einstein at times. To this end, I would like to thank the following

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My family.

And the Master for through Him all things were made, all that is seen and unseen.

In the end all can be summarised by the Psalmist

Omnia in opera sapientia fecisti!

Quam multa sunt opera tua Domine

omnia in sapientia fecisti

impleta est terra possessione tua

Hoc mare magnum et latum manibus ibi reptilia innumerabilia animalia parva cum grandibus

Ibi naves pertranseunt Leviathan istum plasmasti ut inluderet ei

How diverse O Lord are your works!

In wisdom you have made them all- the earth full with your creatures

Behold the sea, wide and vast

Teeming with countless creatures

Living things both great and small, a strange world reserved for the ships

For Leviathan, the dragon you made to play with

Psalm 103: 24-26 Latin Vulgate and Revised Standard Version Translation

AD MAJOREM DEI GLORIAM

This work is dedicated to all battlers especially

Brigadier General Benjamin R Vallejo (Armed Forces of the Philippines) (1927-1991)

Jaime J Cabrera (1938-2002)

Curator of Molluscs, National Museum of the Philippines

Professor Fernando Dayrit,

Emeritus Curator of Molluscs, National Museum of the Philippines

Professor Dr Edgardo D Gomez, University of the Philippines

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Reverend Father Dr Bienvenido Nebres SJ, Ateneo de Manila University

My friends and students

And to those who labour for the good of the Philippines and not expect any reward

STATEMENT OF ACCESS

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[Electronic signature affixed]

BENJAMIN VALLEJO JR

31 January 2000
and
19 August 2003

STATEMENT ON SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from published and unpublished work of others has been acknowledged in the text and a list of references is given.



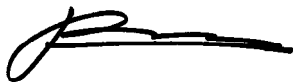
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The following institutions or persons contributed primary and secondary material and or funding in this thesis. The nature of these contributions are indicated

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ABSTRACT	
ACKNOWLEDGEMENTS	
FRONTISPIECE	
DECLARATION	
STATEMENT OF ACCESS	
TABLE OF CONTENTS	
LIST OF FIGURES	
LIST OF TABLES	
General Introduction	1
1.1 FACTORS AFFECTING DISTRIBUTION OF BIOTA	1
1.2 BASIN ISOLATION, EAST-WEST ISOLATION AND ARCUATE RANGES	5
1.3 THE SCOPE AND AIM OF THIS THESIS	9
Geology , Physical Oceanography and Climate of the Indo West Pacific (IWP)	10
2.1 GEOLOGICAL EVOLUTION OF SOUTHEAST ASIA, WITH EMPHASIS ON THE PHILIPPINES	11
2.2 THE PRESENT PHYSICAL OCEANOGRAPHY AND CLIMATE	15
2.3 ARE PRESENT CLIMATE AND OCEANOGRAPHIC PATTERNS SIMILAR TO THOSE OF THE PAST?	18
2.4 DISCUSSION	20
2.5 CONCLUSION	22
Materials and Methods of Biogeographical Analyses	24
3.1 MATERIAL	24
3.2 METHODS	26
3.3 INTRODUCTION TO THE GASTROPOD TAXA INVESTIGATED	36
Range and Distribution of Rocky Shore Gastropods in the Philippines	41
4.1 INTRODUCTION	41
4.2 MATERIAL	43
4.3 METHODS	43
4.4 RESULTS	44
4.6 DISCUSSION	75
4.7 CONCLUSIONS	85
The biogeography of intertidal and shallow-water <i>Conus</i>: environmental heterogeneity and the basin isolation hypothesis	87
5.1 INTRODUCTION	87
5.2 MATERIAL	90
5.3 METHODS	99
5.4 RESULTS	105
5.5 DISCUSSION	131
5.6 CONCLUSIONS	140
The biogeography of a sand dwelling coral reef gastropod, <i>Oliva</i>, in the Philippines	142
6.1 INTRODUCTION	142
6.2 MATERIAL	145
6.3 METHODS	145
6.4 RESULTS	148
6.5 DISCUSSION	167

6.6 CONCLUSIONS	170
Inferring the mode of speciation in Indo-West Pacific (IWP) <i>Conus</i>	171
7.1 INTRODUCTION	171
7.2 MATERIALS AND METHODS	176
7.3 RESULTS	179
7.4 DISCUSSION	184
General Discussion, Synthesis and Hypotheses	188
8.1 INTRODUCTION	188
8.2 THE HISTORICAL NATURE OF THE IWP AS THE CENTRE OF MARINE SPECIES DIVERSITY	189
8.3 THE NATURE OF BASIN ISOLATION: GEOGRAPHICAL RANGE AND MORPHOLOGICAL DIVERSITY OF REEF GASTROPODS	192
8.4 THE SPECIES-AREA RELATIONSHIP AND CONSTRAINTS TO DISTRIBUTION	193
8.5 THE CENTRE OF ORIGIN HYPOTHESIS RE-EXAMINED: THE POSSIBLE SIGNIFICANCE OF DUAL DISTRIBUTIONS AND ENDEMIC SPECIES.	194
8.6 PHILIPPINE MARINE BIOGEOGRAPHICAL REGIONS: DEFINED BY EAST-WEST SEPARATION, OCEANIC BASINS AND MACROECOLOGICAL FACTORS	197
8.7 GENERAL CONCLUSIONS	199
LITERATURE CITED	203

APPENDICES

- Appendix 1 Field Sites
- Appendix 2a OGU's investigated
- Appendix 2b *Oliva* species richness and OGU area
- Appendix 2c Basin Isolation data
- Appendix 3 UPV Symposium Paper
- Appendix 4 *Conus* habitat frequencies in each OGU
- Appendix 5 Cone snails of the Philippines
- Appendix 6 *Oliva* species determined from DMNH material
- Appendix 7 *Oliva* species recorded from the Philippines
- Appendix 8 Philippine Cones Database

	LIST OF FIGURES	PAGE
Chapter 1		
	Figure 1.1 The arcuate centre of IWP marine taxonomic diversity	6
Chapter 2		
	Figure 2.1 The Philippine archipelago	11
	Figure 2.2 The Philippines in the Pleistocene	14
	Figure 2.3 Western Pacific currents	18
	Figure 2.4 Major surface currents	19
Chapter 3		
	Figure 3.1 Sites of collection in the Philippines	27
	Figure 3.2 OGU diagrams	28
	Figure 3.3 Areography	32
Chapter 4		
	Figure 4.1a <i>Clypeomorus</i> distribution	45
	Figure 4.1b <i>Clypeomorus</i> distribution	46
	Figure 4.1c <i>Nerita</i> distribution	47
	Figure 4.1d Disjunct distribution in <i>Nerita</i>	48
	Figure 4.1e Distribution of uncommon <i>Nerita</i>	49
	Figure 4.1f Distribution of muricids	49
	Figure 4.1g Distribution of restricted range muricids	50
	Figure 4.1h Distribution of littorinids	51
	Figure 4.2 PCA biplot of macroecological variables in Littornidae	59
	Figure 4.3a PCA biplot of macroecological variables in <i>Nerita</i>	60
	Figure 4.3b PCA PC1 and PC3 biplot of macroecological variables in <i>Nerita</i>	61
	Figure 4.3c PCA PC2 and PC3 biplot of macroecological variables in <i>Nerita</i>	62
	Figure 4.4 PCA biplot of macroecological variables in <i>Clypeomorus</i>	63
	Figure 4.5 PCA biplot of macroecological variables in Muricidae	64
	Figure 4.6 Shape of geographical ranges	70
	Figure 4.7 Range size frequency distribution and species number	73
	Figure 4.8 Provinciality graphs	74
Chapter 5		
	Figure 5.1 The Philippine archipelago and oceanic basins	88
	Figure 5.2a PCA biplot of macroecological variables in Philippine <i>Conus</i> assemblages	108
	Figure 5.2b PCA PC1 and PC3 biplot of macroecological variables in Philippine <i>Conus</i> assemblages	109
	Figure 5.3 SPAR curves for Philippine <i>Conus</i>	114
	Figure 5.4 Provinciality graph	116

	Figure 5.5a-c	Trends in basin z parameters	117
	Figure 5.6a-b	Positive correlaton of basin isolation with species diversity and provinciality	118
	Figure 5.7	Index of basin isolation and species loss	121
	Figure 5.8	Potential <i>Conus</i> extinction rates	122
	Figure 5.9	Frequencies of H1 and H2 habitats	124
	Figure 5.10	<i>Conus</i> range shapes	128
	Figure 5.11a-b	<i>Conus</i> distributions	129
	Figure 5.12	Range size frequency distribution and species number	130
Chapter 6			
	Figure 6.1	<i>Oliva</i> metrics	147
	Figure 6.2	<i>Oliva</i> distributions	150
	Figure 6.3	SPAR curve in Philippine <i>Oliva</i>	151
	Figure 6.4	Provinciality plot	153
	Figure 6.5	Range size frequency distribution and species number	155
	Figure 6.6	Range shape in <i>Oliva</i>	157
	Figure 6.7	PCA biplot of macroecological variables in Philippine <i>Oliva</i> assemblages	160
	Figure 6.8	Species number and frequency of occurrence	161
	Figure 6.9	Morphometric discriminant plots	166
Chapter 7			
	Figure 7.1	Barraclough's models	175
	Figure 7.2	<i>Conus</i> phylogeny	178
	Figure 7.3	Sympatry and node height relationship	180
	Figure 7.4	Sympatry and node height relationship in the Ebraeus clade	182
	Figure 7.5	Trends in sympatry in habitat specific and non-habitat specific <i>Conus</i>	183
	Figure 7.6	Relationship between pelagic larval stage and node height	184
Chapter 8			
	Figure 8.1	Marine biogeographical regions of the Philippines	198

		LIST OF TABLES	PAGE
Chapter 4			
	Table 4.1a	Geographic unit loadings on PC axes in <i>Nerita</i>	54
	Table 4.1b	Geographic unit loadings on PC axes in <i>Clypeomorus</i>	55
	Table 4.1c	Geographic unit loadings on PC axes in Muricidae	57
	Table 4.1d	Geographic unit loadings on PC axes in Littorinidae	58
	Table 4.1e	Pearson and Randall correlations	59
	Table 4.1f	Rocky shore gastropod species diversity correlations with macroecological factors	65
	Table 4.2	Areographic summaries	66
	Table 4.3	Linear regression of frequency of occurrence and range size	67
	Table 4.4	Area, site number, species diversity, c and z parameters	68
	Table 4.5	Basin and area effects on species diversity	72
Chapter 5			
	Table 5.1a	OGU attributes	90-91
	Table 5.1b	<i>Conus</i> species recorded in each OGU	92-98
	Table 5.2	List of shallow water <i>Conus</i> species used in life history and habitat analyses	102
	Table 5.3	Habitat characteristics of <i>Conus</i>	104
	Table 5.4a	Pearson and Randall correlations in PCA analyses	107
	Table 5.4b	<i>Conus</i> species diversity correlations with macroecological factors	110
	Table 5.5	Area, site number, species diversity, c and z parameters	112
	Table 5.6	ANCOVA table of basin and bioregion effects	113
	Table 5.7	ANCOVA table for range size, habitat availability and occurrence frequency in Philippine <i>Conus</i>	125
	Table 5.8	Results of stepwise multiple regression on species diversity and habitat type in Philippine <i>Conus</i>	126
Chapter 6			
	Table 6.1	Habitat attributes of Philippine <i>Oliva</i>	144
	Table 6.2	Number of species of <i>Oliva</i> in the Philippine oceanic basins	148
	Table 6.3	SPAR estimates	152
	Table 6.4	Species-area regression statistics	152
	Table 6.5	Species number and frequency of occurrence in each OGU	154
	Table 6.6	PC loading of geographical units	159
	Table 6.7	Stepwise regression statistics	162
	Table 6.8	Classification statistics	164- 165
Chapter 7			
	Table 7.1	<i>Conus</i> species used in the mode of speciation study	177