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. Triangualar shaped or narrow ranges are typical of carnivorous taxa. Narrow, overlapping distributions are more common in the central Philippines.

The frequency of range sizesin 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

Professor Dr Lilia Rabago, University of the Philippines Integrated School

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

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[Electronic signature affixed]

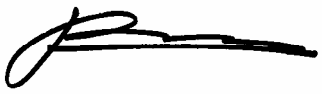
BENJAMIN VALLEJO JR

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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STATEMENT ON THE CONTRIBUTION OF OTHERS

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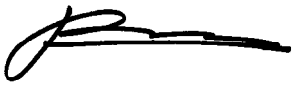

Benjamin Vallejo Jr 2 September 2003