SILLIMAN JOURNAL

A JOURNAL, PUBLISHED TWICE YEARLY,
DEVOTED TO DISCUSSION AND INVESTIGATION
IN THE HUMANITIES, SOCIAL SCIENCES, AND SCIENCES

VOLUME 42 NO.1 JANUARY -JUNE 2001

ISSN 0037-5284

SILLIMAN JOURNAL

Volume 42 Number 1, January-June 2001

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The SILLIMAN JOURNAL *is published twice a year under the auspices of Silliman University, Dumaguete City, Philippines. Entered as second class mail matter at Dumaguete City Post Office on September 1, 1954.*

ISSN 0037-5284

Annual subscription rates are at PhP400 for local subscribers, and $25 for overseas subscribers. Subscriptions and orders for current and back issues should be addressed to:

The Circulation Manager
SILLIMAN JOURNAL
Silliman University Main Library
Dumaguete City, Negros Oriental
6200 PHILIPPINES

Issues are also available in microfilm format from:

University Microfilms International
300 N. Zeeb Road, Ann Arbor
Michigan 48106 USA

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Imaging by Philip Van Peel
Photo credits: Cynthia N. Dolino, Rafe M. Brown and Angel C. Alcala
Cover and book design by Philip Van Peel

Cover photo: P._spelaeus

Printed by SU Printing Press, Dumaguete City

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Notice to Authors

The Silliman Journal welcomes contributions in all fields from both Philippine and foreign scholars, but papers should preferably have some relevance to the Philippines, Asia, or the Pacific. All submissions are refereed.

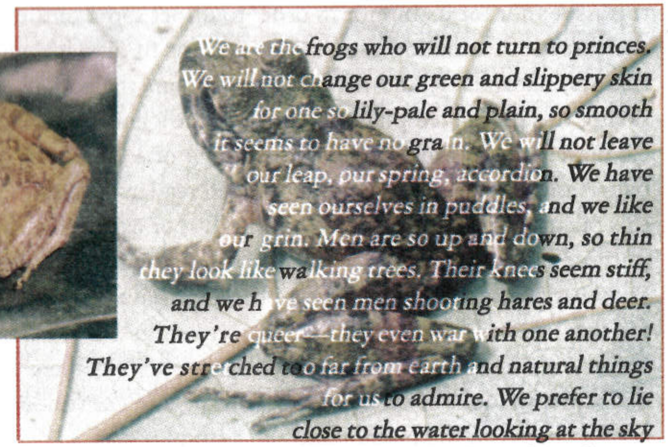
Articles should be products of research, taken in its broadest sense; a scientific paper should make an original contribution to its field. Authors are advised to keep in mind that Silliman Journal has a general and international readership, and to structure their papers accordingly.

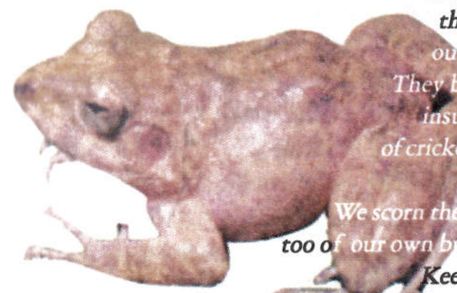
Silliman Journal also welcomes the submission of "Notes," which generally are briefer and more tentative than full-length articles. Reports on work in progress, queries, updates, reports of impressions rather than research, responses to the works of others, even reminiscences are appropriate here. Book reviews and review articles will also be considered for publication.

Manuscripts should conform to the conventions of format and style exemplified in this issue. Whenever possible, citations should appear in the body of the paper, holding footnotes to a minimum. Documentation of sources should be discipline-based. Pictures or illustrations will be accepted only when absolutely necessary. All articles must be accompanied by an abstract and must use gender fair language. All authors must submit their manuscripts in duplicate, word-processed double-space on good quality paper. A diskette copy of the paper, formatted in MSWord 6.0 should accompany the submitted hard copy.

The Editorial Board will endeavor to acknowledge all submissions, consider them promptly, and notify authors of its decision as soon as possible. Each author of a full-length article is entitled to 25 off-print copies of his/her submitted paper. Additional copies are available by arrangement with the Editor or Circulation Manager before the issue goes to press.

EDITOR'S NOTES





We are the frogs who will not turn to princes.
We will not change our green and slippery skin
for one so lily-pale and plain, so smooth
it seems to have no grain. We will not leave
our leap, our spring, accordion. We have
seen ourselves in puddles, and we like
our grin. Men are so up and down, so thin
they look like walking trees. Their knees seem stiff,
and we have seen men shooting hares and deer.
They're queer—they even war with one another!
They've stretched too far from earth and natural things
for us to admire. We prefer to lie
close to the water looking at the sky
reflected; contemplating how the sun,
Great Rana, can thrust his yellow, webbed foot
through all the elements in a giant jump;
can poke the bottom of the brook; warm
the stumps for us to sit upon; and heat
our backs. Men have forgotten to relax.
They bring their noisy boxes, and the blare
insults the air. We cannot hear the cheer
of crickets nor our own dear booming chugs.
Frogs wouldn't even eat men's legs.
We scorn their warm, dry princesses. We're proud
too of our own big-eyed brides with bouncing strides.
Keep your magic. We are not such fools...
We may begin from the same tadpoles, but
we've thought a bit, and will not turn to men.

from REBELS FROM FAIRY TALES, Hyacinthe Hill

IN THIS ISSUE: According to legends, Cellini, the great Italian Renaissance goldsmith wept because he knew he could never equal the filigreed golden beauty in the toad's eye.[1] To experience some of the sense of mystery and passion that biodiversity conservation can engage among its advocates, I have had to turn—strange as it may seem—to literature, the ground most familiar to me, in seeking inspiration for this editorial. I have purposely chosen Hyacinthe Hill's *Rebels from Fairy Tales* not merely as a decorative complementary piece to the ex quisite photographs that grace both the cover and the frontispiece of this issue; nor for its humor in order to dispel some of the gloom that the threat of extinction causes us to feel, or to distract our conservationists, naturalists, and field biologists from the serious business of saving this plundered planet. Indeed, to use a poem as the philosophical underpinnings for the thematic design of a collection of scientific papers is to invite among serious-minded readers questions about how this poem might contribute to our survival or extinction, which is the purpose of this collection. Indeed, some of them might be moved to ask what bearing does the science of ecology have on literary studies or for that matter, vice versa? Or what crossings are possible between literary studies and environmental discourse? Needless to stress, to doubt the wisdom of such a choice is to negate the fundamental connection between the human and the natural world.

In this little fable, the author invites us on an imaginary excursion into the natural world through the eyes of a frog. From the Russian formalist literary tradition, this device is known as *ostranenie*[2] or quite simply, defamiliarization, the object purpose of which is to render the familiar unfamiliar in order to provide readers a fresh experience such as, in this poem for instance, a new way of looking at nature and the values that are assigned to or denied it, or the way it envisions the relationship between humans and nature. Specifically, it provides an opportunity to examine the metaphorical portrayal of nature in a poetic genre and how such artistic construction has come to shape our current perception of the environment. Suffice to say that the message of this little fable is self-evident—materialism, environmental degradation, species extinction, ozone depletion, issues which are at the heart of biodiversity conservation programs.

The point of this fable then is to foster awareness of the ethical and aesthetic questions engendered by environmental crises and the role of language and literature in conveying values with profound ecological ramifications. It is here to establish significant links between literary and scientific approaches to the environment. Finally, the reason for its being here is to suggest yet one more way, still one more route through which we may contribute to the daunting but urgent task of conservation by understanding the interdependencies inherent in the connection between humans and nature.

In editing this particular collection, I find myself in a mediating position between science and literature. While this interdisciplinary link affords me the opportunity to integrate my personal intellectual interests and my political commitments, it also grants me the special privilege of having one foot in literature and the other, albeit vicariously, on the ground. Part of my agenda as editor of this special issue is to use this interdisciplinary approach to make sense not just of our relation to a text, but to the natural and physical world in which the text as well as its reader exist. In an era of intensifying ecological crisis and increasing social conflict over the management and distribution of natural resources, it will not be a misguided effort to forge vital connection between literary and scientific approaches to the environment.[3]

Meanwhile, to turn now to the pressing concerns of this volume, survival is what this issue is all about and our message is one of hope, for there can be no other. As the legendary Stephen Hawking reassures us, "there is still a great deal we don't know or understand about the universe but we may not be forever doomed to grope in the dark," in our case, for as long as there are groups like the Wildlife Conservation Society of the Philippines and there are conservationists, field biologists, naturalists such as those represented in this volume who will light our way in the dark, and there is a medium like *Silliman Journal* to spread the splendid news.

This volume compiles into a special issue the proceedings of the 10th annual Symposium and Scientific Meeting of the Wildlife Conservation Society of the Philippines, Inc. on the theme "Biodiversity Research and Management: Ten Years of Progress and Ten Years of New Challenges" held at Silliman University on April 2001. A professional organization of wildlife researchers, managers, scientists, and conservationists, the WCSP is dedicated to protecting and promoting a world rich in wildlife. Through its pioneering work in environmental education, collaborative research, and exchange of expertise through technical assistance and training, it aims to raise public awareness about caring for nature in order to sustain biological diversity.

The articles in this collection address the disturbingly accelerating biodiversity loss by focusing on some of the key issues and programs in biodiversity conservation that have been undertaken in this country over the last ten years. Collectively, they illustrate the highly complex and multifaceted task of conservation and demonstrate how widespread the problem, how daunting the task. Individually, each article is a record of huge efforts, endless patience, and passionate commitment of their respective authors to biodiversity conservation. Echoing Rachel Carson, the authors in this volume remind us that while it took "millions of years to produce the life that now inhabits the earth—eons of time in which that developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings," it took but a remarkably short space of time for the thoughtlessness and greed of humans to plunder this planet and leave it reeling from their depredations.

In keeping with the conference theme, the article on the *State of Philippine Herpetelogy and the Challenges for the Next Decade* by Rafe M. Brown, Arvin C. Diesmos, and Angel C. Alcala opens this issue with a critical assessment of the state of herpetological studies in this country and the dramatic developments in research on Philippine species, especially amphibians in the last 10 years. The paper, however, does not only confine itself to an objective assessment but also comments on the moral, philosophical, and political aspects of biodiversity and the strategies for conserving and protecting it. Ironically, as the paper points out, the rapid progress made in the identification of previously unrecognized species has not only rendered even recent field guides out of date, but has also outpaced the current efforts in comprehensive taxonomic investigations. In the several attempts that have been made to assess the current status of threatened Philippine amphibians and reptiles in the last decade, the general lack of knowledge, the dearth of basic baseline data, the absence of a coherent program, public disinterest, and bureaucratic obstacles to research have been cited by the authors as among the most difficult challenges of conservation work in this country.

Following pretty much along the same line, Lawrence R. Heaney's article, *A Decade of Research on Philippine Mammals: Progress and Challenge* critically examines the state of research on Philippine mammals over the last 10 years and reviews the importance of such studies for the improved understanding of native land mammal species. On the one hand, Heaney's paper acknowledges a number of significant studies that have yielded equally significant data on the

conservation status of mammals, distribution, and abundance for most species that field biologists need in order to estimate their decline. At the same time, it also underscores the urgent need for more essential information to guide crucial conservation strategies.

In the next article on the *Negros Rainforest Conservation Project: Past, Present, and Future*, Craig Turner, Eleanor Slade, and Gerardo Ledesma introduce the work carried out by the Negros Rainforest Conservation Program to promote the development of an integrated, community-driven conservation initiative for the sustainable management of the biodiversity of the North Negros Forest Reserve. Many of the projects, and much of NRCP's accomplishments, have been achieved in collaboration with the Coral Cay Conservation of the United Kingdom. Together, their collective efforts are aimed at gathering valuable biodiversity inventory data, and promoting the use, maintenance, and enhancement of the knowledge, innovations, and practices of local communities that conserve and use biodiversity.

The next article by Rafe M. Brown and Arvin C. Diesmos on the *Application of Lineage-Based Concepts to Oceanic Island Frog Populations: The Effects of Differing Taxonomic Philosophies on the Estimation of Philippine Biodiversity* goes against the grain of conventional practice in taxonomic studies to argue for the adoption of the Evolutionary Species Concept or the General Lineage Concept for estimating species diversity and endemism in the Philippines. As the authors maintain, the application of these concepts results in the recognition of taxa in a manner that is logically consistent with known evolutionary history, given the unique geological history of the islands of the Philippines. The application of lineage-based concepts, according to the authors, has one more strength and that it can reinforce more realistic estimates of Philippine diversity and hence promote conservation efforts.

Jodi L. Sedlock's article on the *Autecology and the Conservation of Insectivorous Bats on Mt. Makiling, Philippines* provides important information on habitat use, diet, foraging mode, reproductive timing, and roosting preferences of 22 species of insectivorous bats the author studied on Mt. Makiling. In this paper, the author also examines the potential adverse effect of habitat disturbance and loss on coexistence mechanisms, such as habitat selection and the partitioning of resource abundances, which maintain local bat diversity

The following article by Carlo C. Custodio and Norma M.

Molinyawe on *The Nipas Law and the Management of Protected Areas in the Philippines: Some observation and Critique* is a critical review of the National Integrated Protected Areas System whose passage into a law in July 1991 represented a significant breakthrough in the management of protected areas in this country. The authors claim that despite the grand objectives of the NIPAS Law, its actual implementation remains contentious. The authors' critique focuses on the salient points of the NIPAS, examines some of the inherent weaknesses in its provisions, and analyzes the problem areas that the authors believe impede the effective compliance of its requirements.

Finally, this collection includes in the section on *Notes* an institutional report by Angelita M. Cadeliña and Mirasol N. Magbanua on *The Centrop Experience: Past, Present and Future* to present some of the accomplishments of the center in the area of community-based biodiversity conservation, wildlife conservation, breeding and management, environmental awareness, and advocacy campaigns. Lending a poignant note to these accomplishments is the specter of chronic shortage of resources—one of the challenges of conservation work in this country—which makes the Center's successes all the more remarkable.

By way of concluding the presentation of these articles, let me reiterate some of the salient issues in conservation, among the many that have been raised in this collection. The articles in this volume stress in varying degrees of urgency the serious threat to the environment posed by ecological degradation and its corollary—biodiversity loss. In order to bring about sustainable resource conservation and management, the articles propose the adoption of several different approaches for managing our forests and biodiversity.

First and foremost, the authors, despite the diversity of their specializations, are unanimous in underscoring the importance of formulating initiatives for conservation and management of resources that derive from a set of clear objectives, well-defined mechanisms for action, and a strong commitment from all stakeholders. As practicing conservationists, the authors rightly recognize that halting the process of degradation and species loss requires specialized solutions and an understanding of ecological processes. Second, the articles uniformly advocate for a more involved participation of communities and giving them greater autonomy, roles, and responsibilities in the management

and conservation of resources. A third strategy presented in this collection calls for the appropriate conservation of important ecosystems and habitats as a necessary precondition for maintaining viable populations of species, whether plant or animal. Fourth, at least three of the articles put forward an impassioned argument for undertaking intensified ecological surveys and taxonomic investigations needed to constitute an adequate data on species diversity, population, locations and extent of habitat, major threats to different species, among others, as basis for designing a proper strategy for conservation. In this regard, the importance of mapping the protected areas of the country showing their contiguity with the existing reserve and protected areas in order to provide a way for determining possible corridors, habitat contiguity, and buffer zones, as well as facilitate biodiversity conservation cannot be overemphasized.

Finally, the issues of wildlife trade and the need to control it through better enforcement and implementation of wildlife protection acts, review of existing governmental policies, and education campaigns; the use of voluntary action through the involvement of local communities in order to complement government efforts and also to play the role of environmental watchdogs capable of influencing public policies; the involvement of the private sector; and, information networking for effective generation and dissemination of data have all been addressed, in varying degrees of emphasis, in this collection.

These articles represent the authors' courageous standpoints as well as commitments to their convictions and to their communities. They exemplify moments of assertion—moments of living out loud when discovering what they believe in and acting on it becomes paramount in their lives. Throughout this collection, the authors have not only told us about their projects, but about their own stories—about themselves. Individually they give voice to the human capacity to make sense of things and to construct a meaningful and well-measured life, a life whose commitments they are willing to make public.

It is my hope that readers of these articles will be encouraged by what they have read here to look at the world around them—and to do so with renewed interest, enhanced competence, and deepened pleasure because of what is suggested in these writings about moral responsibilities and a sense of stewardship for the environment. Through this collection, we too might accept the challenge to contribute to the urgent task of conserving biological diversity.

With much pleasure I turn now to my other duty as Chair of the Editorial Board of Silliman Journal for the pleasant task of welcoming and introducing the new overseas specialists who will serve as international members of the Editorial Board. They are Dr. Rozzano C. Locsin, Dr. Marc L. Miller, Dr. Alison J. Murray, Dr. William F. Perrin, and Dr. Marcy E. Schwartz.

Dr. Rozzano C. Locsin is an Associate Professor of the College of Nursing at the Florida Atlantic University in Boca Raton, Florida. Himself a regular contributor and reviewer of this journal, as well as other various international nursing journals, Dr. Locsin has been a recipient of the Fulbright Scholar Award to Thailand and Uganda. In recognition of his achievements in the field of nursing education both in this country and outside, Silliman University awarded him the Outstanding Sillimanian Award a few years ago. In time for Silliman University's centennial celebration in August last year, Dr. Locsin returned to his Alma Mater to launch his book, *Advancing Technology, Caring, and Nursing* published by Auburn House in Connecticut.

Dr. Marc L. Miller is a Professor at the School of Marine Affairs of the University of Washington. A specialist in Maritime anthropology, Dr. Miller's distinguished career branches out to cognitive anthropology, anthropology of work and leisure, social and cultural change, coastal zone management, fishery management, environmental protection, and recently, ecotourism—interests that brought him to Silliman campus as Visiting Lecturer at the Department of Anthropology and Sociology in the first semester of last year.

Dr. Alison J. Murray is a personal friend from my University of Sydney days. When I entered the Southeast Asian Studies Department of the University of Sydney as a doctoral student, she was then a postdoctoral fellow on the final stages of completing into a book her provocative doctoral thesis on the life of sex workers and traders in Jakarta. Oxford University Press in Singapore published this book, *No Money No Honey: A Study of Street Traders and Prostitutes in Jakarta* in 1991. Dr. Murray's varied areas of specialization, as fascinating as the person that she is, and informed by cultural studies perspective, include East Timor and Indonesia, Southeast Asian urban social geography, subcultures and performance, sexuality, sex work, HIV and AIDS discourses, AIDS and development, queer theory, iconography and the body, and cultural anthropology. Dr. Murray is back as Lecturer in our

old department, the Southeast Asian Studies Department of the University of Sydney, with a new book, just as provocative as the first, entitled *Pink Fits: Sex, Subculture & Discourse in the Asia-Pacific* published by Monash Asia Institute, Monash University, Melbourne.

Dr. William F. Perrin is a Senior Scientist (Supervisory Fishery Biologist-Researcher), at the Southwest Fisheries Science Center, La Jolla, California. Dr. Perrin's distinguished reputation rests on his extensive research on marine mammals. In particular, his areas of specialization include population biology of cetaceans (morphological and molecular systematics, ecology, population assessment, growth and reproduction). He is professionally affiliated with the American Society of Mammalogists; Society for Marine Mammalogy; Research Associate in Marine Mammals, Los Angeles County Museum; Research Associate in Vertebrate Zoology, Smithsonian Institution; Adjunct Professor, Marine Biology, Scripps Institution of Oceanography. Among the many scientific committees that have the good fortune of his devoted service as member include the Species Survival Commission, IUCN; Scientific Councilor, Convention on Migratory Species of Wild Animals; the Scientific Committee, International Whaling Commission; the Marine Mammal Project, U.S.-Russia Envir. Agrmt.; Chairman, Cetacean Specialist Group, IUCN, 1984-1990; and the Committee of Scientific Advisors to U.S. Marine Mammal Commission.

Silliman Journal has Dr. Laurie Hutchison Raymundo to thank for this introduction to Dr. Marcy E. Schwartz, Associate Professor of Spanish and academic director of the Latin American Studies Program at Rutgers University in New Jersey. Dr. Schwartz has published on writers from the Southern Cone and Peru, and studies on urban narrative, the politics of translation, and the interaction of literature and other arts in Latin America. She has published two books, *Writing Paris: Urban Topographies of Desire in Contemporary Latin American Fiction*, and *Voice-Overs: Translation and Latin American Literature* (SUNY Press). She is currently working on photographic and literary collaborations.

Silliman Journal is singularly honored to have the participation of these distinguished scholars and academics in the International Editorial Board. My colleagues in the Editorial Board join me in extending this warm welcome to them as we look forward to a productive period of collaboration and journal publication. Starting this year, Dr. Locsin, Dr. Miller, Dr. Murray, Dr. Perrin, and Dr. Schwartz join

Dr. Eberhard Curio and Dr. Lester Edwin J. Ruiz in our international editorial board.

Much of what we have achieved in the last three years since we started inviting overseas specialists would not have been possible without the involvement of Dr. Efren N. Padilla, Chair of the Sociology Department of the California State University at Hayward, Dr. Hernane Meñez of the Smithsonian Institution in Washington, D. C., and Dr. M. William Steele, Director of the Institute of Asian Cultural Studies at the International Christian University in Tokyo. Our immeasurable debt to them for generously sharing their time and expertise with Silliman Journal.

Acknowledgments

Editing a journal is a monumental task that an editor cannot accomplish alone. It calls for the dedication and involvement of many people from the gathering of manuscripts to the realized product. Thus a collection of this kind and complexity is invariably a collaborative undertaking.

In my many other debts, more than there is space to repay, I want particularly to acknowledge the authors in this collection for their intellectual energy and receptivity to critical feedback, their diligent and inspired revisions, and their patience during the long months it has taken to bring this issue to press. In editing their work they have allowed me to enter their world and experience, even if only vicariously, the passion that animates their scientific inquiry. In trying to follow, in my mind, the trail they are blazing in the name of conservation across 7,100 islands of this archipelago republic to remote places I have heard only for the first time, I am dazzled. Theirs is the work, mine the pleasure of participation.

It gives me great pleasure to acknowledge the brilliance and perspicacity of our reviewers for whom any author would have been grateful. Some of them went to extraordinary lengths to provide the authors with substantial, insightful, and generous commentary, often straight into the text to provide preliminary editing, sparing me many hours of editorial work. In our experience of journal publication, their promptness in returning the manuscripts to their respective authors is astoundingly without precedents.

As usual, Prof. Eberhard Curio has been unfailingly, inestimably helpful. Solely through his invaluable efforts, I have been introduced, from among his extensive network of connections, to some of the most critically perceptive yet generous readers and reviewers who demonstrated great skill and tact in reading the manuscripts. His passion for conservation has offered me a model of intellectual rigor and commitment to aspire to.

The pressure at times was unbearable, the work too exacting and exerted multiple demands on one's energies. During those times, I found an unexpected reservoir of encouragement in a friend I have yet to meet in person. Working with her on this volume has been a serendipitous turn of events. To Maren Gaulke, whose devotion to conservation is matched only by her immense knowledge of herpetology, for having been the unexpected exhilaration that she was—inadequate words of thanks.

Several colleagues and friends have made the preparation of this enormously challenging project worth every frustrating moment. Much appreciation goes to my colleague and technical editor, Philip van Peel, whose good humor and equanimity under stress saw us through the inevitable agony and uncertainty associated with this project. His creative vision and aesthetic sensibility transformed the manuscripts into a beautiful and useful volume and gave its cover an exquisite, eye-catching appeal, despite my constant interference.

The beautiful photograph of the Negros cave frog (P._spelaeus) that graces this issue's cover is Rafe Brown's contribution to this volume. Prompt in returning revisions, receptive to critical feedback, can be relied on to keep promises, and quick to offer his expertise, Rafe is every journal editor's dream contributor. To him—the other unexpected exhilaration of this project—sincere thanks extend well beyond this page.

The fine photographs that inspired my editorial notes are from Dr. Angel C. Alcala—his support of Silliman Journal illuminates our continuing efforts to maintain SJ's international standard as a scholarly publication.

Much of the actual running around and the gathering of manuscripts were the deeply-appreciated contribution of Cynthia N. Dolino who ably connected us with the Biology Department, the Silliman University Angelo King Center for Research and Resource Manage-

ment, and the contributors. Her calm presence and cheerful disposition during the critical stages of journal production kept us focused on the project and on our deadline. The cave photo which provides the backdrop (and the habitat) for the Negros cave frog in our cover is from her.

As always Silliman Journal owes an immeasurable debt of gratitude to the Department of English and Literature for providing it a home, lending it an email address, and allowing it unlimited use of equipment during journal production. During the weeks that the preparation of this volume had taken up all my energy and attention away from my administrative duties as chair of department, my colleagues showed only great understanding and unflagging support.

Just as I have been fortunate with colleagues at the Department of English and Literature, I have also been equally blessed with colleagues in the Editorial Board who sustain my creativity by letting me be. Their confidence in my ability to deliver is the impetus behind much of the creative impulse that has generated finished products such as this.

Although there had been moments in the past when Silliman Journal itself was threatened with extinction and we felt like endangered species ourselves because of chronic budgetary constraints, at no moment since I took over as editor and chair of the Editorial Board did I ever doubt that the university would sustain our effort. In our last issue, I expressed the hope that President Agustin A. Pulido would continue to demonstrate his Midas touch and I am happy to note in this issue that he has not disappointed us. With his support, he has ensured SJ's continued presence in the libraries of some of the most prestigious academic institutions in the world. Now we can confidently plan the next issues way ahead of time.

This issue is special in many ways—it is an aggregation of articles on a single theme; it features the proceedings of a specific conference or symposium, such as the WCSP; and it owes its life from the generous endowment of the Wildlife Conservation Society of the Philippines. I thank the Biology Department, through its Chair, Prof. Mirasol N. Magbanua, for facilitating this grant. And finally, for giving us the finished product that we expect it to be, many thanks to Silliman University Press.

On a personal note, my father, whose idea of conservation was

filling our backyard with trees and bananas, walked with me through the pages of these editorial notes. Stroke has severely damaged his body, deprived him of the ability to speak, and reduced our communication to an extremely limited repertoire of body language. Finding the time to work on this volume in the midst of chairing a department, preparing lectures, marking exams, and fulfilling filial obligations often meant staying in the office and working late into the night and on weekends. During this time, my father showed only remarkable patience for my long hours of absences from home and remained my greatest fan even if this time he could only shake his foot to signify his pride at seeing that, in doing this project, I have learned the lessons he had taught so well:

The wounds of our time are not even ours.
They are our children's.
Such is our ignorance. We cannot see
The choke of refuse where the creek bends,
Or the fish die where the sea begins,
Or the feather or the fur stiff
When the black surf recedes.
Beyond the timber that we splinter
Into the implements of our ease,
Or crush into a pulp so we may write
Our little poems, we cannot see the flood,
The thinning air, the crumbling rockface,
And the futility of our words...."[4]

Ceres E. Pioquinto

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[1] John Caddy, "Eye of the Toad" from *Eating the Sting*.

[2] A concept introduced by Viktor Shklovsky, based on his claim that we can never retain the freshness of our perceptions of objects. From "Art as a Technique."

[3] Ursula K. Heise, "Science and Ecocriticism," *The American Book Review* 18.5 (July-August 1997).

[4] Marne Kilates, "Wounds of our Time," from *Water Poem, Tree Poem*, in *Voices in the Wilderness*: a special issue of Sands and Coral.

THE STATE OF PHILIPPINE HERPETOLOGY AND THE CHALLENGES FOR THE NEXT DECADE

RAFE M. BROWN, ARVIN C. DIESMOS, AND ANGEL C. ALCALA

First, there is a great need for more new basic research focused on biodiversity conservation, including systematics, ecology, behavior, and current patterns of distribution and abundance. Without such fundamental information, conservation planning will be incomplete at best.

Heaney et al., 1999: 315.

The information needed to make sense of Asian herpetology is not lurking in the literature; it is still out there in the rice paddies and in the vanishing patches of montane forest.

Crombie, 1992: 593

ABSTRACT

The herpetological fauna (amphibians and reptiles) of the Philippines is extremely rich in total species numbers, taxonomic diversity, and percent endemism—especially when considered as a function of available land area. The last 10 years of herpetological research in the Philippines have seen a dramatic increase in interest in taxonomy, biogeography, phylogenetic systematics, conservation, and biodiversity of Philippine species, especially amphibians. In the last decade, over 50 previously unrecognized species have been identified. Despite the publication of a recent field guide to the amphibians of the Philippines, available species summaries and diagnostic keys are currently out of date because progress has been so rapid. Revisions of these works are needed but must await the completion of several comprehensive taxonomic investigations currently in progress. In general, amphibians (especially ranid frogs) have received more attention than reptiles.

During the same period, there has been less activity in ecological research and conservation, and little or no activity in disciplines such as behavior, microevolution, reproductive biology, or population biology. In this paper we review a few model studies and point out where others are badly needed.

Available biogeographic analyses, combined with new, unpublished data, demonstrate that the distributions of amphibians and reptiles in the Philippines have been strongly influenced by the mid- to late-Pleistocene formation of several aggregate island complexes as well as by climatic gradients associated with elevation and anthropogenic disturbances (primarily deforestation). Each Pleistocene aggregate island complex is a major center of biological diversity, and within these major (and several other minor) land mass amalgamations, there exist numerous sub-centers of endemism and diversity centered on isolated mountains or mountain ranges. Amphibians and reptiles may represent particularly appropriate model organisms for the study of these lesser centers of biological organization due to their tendency towards finer-scale differentiation and isolation on single montane "islands" and mountain ranges. Several recent studies have begun the process of integrating phylogenetic data, species distribution data, and studies of the process of speciation on unique montane habitats, but many more are needed. In particular, the field of molecular systematics stands out as an immensely powerful set of tools that has yet to be tapped by conservation biologists in the Philippines.

The last decade has seen several attempts to assess the conservation status of many of the Philippines' unique and presumably threatened amphibians and reptiles. These efforts have been hampered by a general lack of knowledge, a paucity of basic baseline survey data, a lack of integration, public disinterest, bureaucratic obstacles to research, and by limitations in resources. The number one cause of amphibian and reptile population declines clearly is catastrophic habitat destruction due to the activities of humans.

Introduction

Situated at the interface between the Oriental and Australian faunal zones is the largely oceanic island nation of the Philippines. The Philippine islands are home to a spectacular and diverse set of amphibian and reptile radiations that have captured the attention and imagination of diversity specialists and biogeographers since the first accounts of Philippine herpetological diversity appeared in the scientific literature (e.g., Boulenger, 1882, 1894, 1920; Peters, 1863; Boettger, 1893; Taylor, 1915, 1918a, 1919, 1920a, 1920b, 1921, 1922a, 1922b; Taylor and Noble, 1924; Noble, 1931; Schmidt, 1935). The career of Edward H. Taylor in the 1920's (Taylor, 1975) brought the Philippines to the forefront of global appreciation of amphibian and reptile diversity as one of the world's major centers of herpetological diversity and endemism. Later taxonomic and biogeographic summaries (Inger, 1954, 1999; Leviton, 1963; Alcala, 1986; Brown and Alcala, 1970a, 1978, 1980, 1994; Allison, 1996; Brown, 1997; Alcala and Brown, 1998) further promoted the recognition of the importance of Philippine herpetological diversity and stressed the unique nature, evolutionary history, and remarkable diversity of Philippine amphibians and reptiles (see also Noble, 1931; Duellman and Trueb, 1994).

The last 10 years in Philippine herpetological research have seen an increase in interest in a diverse range of studies set against the backdrop of an emerging period of unprecedented taxonomic rediscovery, concern for conservation, and an increase in appreciation for biodiversity. The purpose of this paper is to review and analyze the past decade's progress, to consider its significance within the context of the history of Philippine herpetology, and to identify prospects and goals for future research and conservation.

Composition of the last 10 years' published literature

For this review we considered only published papers (or ones that were, at the time of writing, accepted or in press) and unpublished undergraduate honors, M.S. and/or Ph.D. theses. We mention unpublished data (theses and a few papers in review or preparation) in some cases but we can include contracted reports, private papers, or other pseudopublications that have not been or will not be peer reviewed. We have compiled 109 (see Literature Cited section) scientific publications on Philippine herpetology from between the years 1990 and 2001 (Fig. 1). The annual publication rate has remained relatively stable, with notable exceptions (i.e., in 1995 numerous articles were published on reptiles while many articles were published on amphibians in 1999 and 2000). The composition of the last decade's published record was markedly skewed towards research in systematics, taxonomy, biogeography, and species diversity (Fig. 2). The vast majority of the remaining studies consisted of ecological (includes population biology and community studies) and conservation studies and only a very small fraction addressed other subjects (e.g., information on Quaternary herpetofaunal communities; Reis, 1999; Reis and Garong, 2001) or were popular articles that, in part, addressed herpetological topics or biodiversity of amphibians and reptiles (Heaney et al., 2000; Diesmos, 2000, 2001; Brown and Alcala, 2000; Brown et al., 2002).

History of herpetological studies and species diversity in the Philippines

The first published papers on Philippine herpetology included the works of Boettger, Boulenger, Günther, Mertens, Peters, Weigmann, and Stejneger, among others (see Inger, 1954; Bayless and Adragna, 1997; Brown and Diesmos, this volume). This "age of discovery" in Philippine herpetology marked the first exposure of the outside world to Philippine herpetological diversity, and the papers that resulted were almost entirely descriptive in nature. The first worker to concentrate efforts on a comprehensive review of Philippine herpetofauna was Edward Harrison Taylor (1915-1975, see Literature Cited). In his numerous taxonomic works, Taylor recognized a total of 89 amphibians and approximately 253 reptiles. Later, Inger (1954, 1960a, 1960b; see also Hoogstral, 1951) recognized 55 species of Philippine Amphibia, reducing the species level diversity of Philippine Amphibia by application of the Polytypic Species Concept (see Brown, 1997; Brown et al., 2000; Brown and Diesmos, this volume). In the mid-1950s Angel Alcala and Walter Brown began a collaborative review of most major groups of lizards (see also Inger, 1958, 1983; Musters, 1983; Inger and Brown, 1980) in the Philippines and during the course of their field work, published numerous additional species descriptions (see Literature Cited: Alcala, 1955-1986; Alcala and Brown, 1955-1999; Brown and Alcala, 1955-1994; Brown et al., 1997-1999).

During the same period, Alan Leviton systematically reviewed the contents of most Philippine snake genera in his *Contributions to a review of Philippine snakes* series (Leviton, 1955-1983; see also Leviton and Brown, 1958; Inger and Marx, 1965; Inger and Leviton, 1966; Gyi, 1970; McDowel, 1974; Malnate and Underwood, 1988). Alcala (1986; see also Rabor, 1981) summarized some of this taxonomic work, recognizing 66 amphibian and 205 reptile species (see also Afuang, 1995; Gonzales, 1995; DENR and UNEP, 1997). Progress was made towards a synthesis of species diversity by the unpublished works of R. I. Crombie (*pers. comm.*). Crombie's bibliography and annotated checklist have served as the backbone of many working species lists used by researchers in the Philippines in the past decade.

The work of A. Alcala and W. Brown later set the stage for present studies that continue in collaboration with A. Diesmos and R. Brown. Currently, we recognize a total of 101 species (78, or 77%, endemic) of Philippine amphibians (Fig. 3) and an approximate total of 258 (169 or 65% endemic) species of Philippine reptiles (Fig. 4). That estimate will surely increase by 10-20% in the coming years as numerous undescribed species are named in ongoing taxonomic reviews (R. Crombie, *pers. comm*; Diesmos, Brown, and Alcala, unpublished data). Summaries of taxa described in the last decade are presented in Tables 1 and 2.

The vast majority of papers during the last 10 years of progress in classification and recognition of Philippine herpetological diversity have been species descriptions (e.g., Ota and Crombie, 1989; Lazell, 1992; Wynn and Leviton, 1993; Alcala et al., 1998; Brown et al., 1995a, 1999a, 1999b; Brown et al, 1997c, 1999a, 1999b; Lanza, 1999; Gaulke, 2002; Diemos et al., in review), redescriptions of poorly understood taxa (Ota et al., 1993; Brown et al., 1997; Brown et al., 1998), or clarifications of species boundaries (Ota et al., 1989; Brown et al., 1998; Brown et al, 2000a, 2000b, 2000c, 2001; Gumprecht, 2001). Additionally, several important papers have taken the form of more comprehensive reviews of genera or species groups (Gaulke 1992a; Dubois, 1992; Ota and Ross, 1994; Inger, 1996; Bayless and Adragna, 1997; Fritz et al., 1997; Brown et al., 1997a, 1997b, 1999b; Brown et al., 2000a, 2000c; Brown and Diesmos, this volume; Brown and Guttman, in press; McGuire and Alcala, 2000; Dubois and Ohler, 2000; Veith et al., 2000; Helfenberger, 2001). All of these studies have greatly increased recognized species diversity in the Philippines.

In amphibians, the greatest areas of activity have been in ranid frogs. For example, in the *Rana signata* and *Rana everetti* species groups, diversity has increased from two to twelve species (Brown et al, 2000a; Brown and Diesmos, this volume; Brown and Guttman, in press) and platymantine ranid frog diversity has increased from seven (Inger 1954) to more than 25 species (Alcala and Brown, 1998, 1999). We now know that the species diversity of Philippine flying lizards (genus *Draco,* 10-12 species; McGuire and Alcala, 2000) is closer to original estimates of Taylor (1922a, who recognized 11 species) than it is to later estimates of Inger (1983), who recognized three species (see also Musters, 1983). In total, over 50 previously unrecognized species have been identified in the past decade. Thirty-two of these have been formally named or resurrected from the synonymies of widespread polytypic species complexes (14 reptiles and 18 frogs). At present, more than 15 endemic Philippine frog species await description (Diesmos, Brown, and Alcala, unpublished data), and we suspect that many more await discovery.

Some recent discoveries have been truly spectacular. A new, very distinctive, endemic Philippine genus (*Parvoscincus*) of scincid lizards was discovered in the last decade (Ferner et al., 1997), and further generic subdivision of one group of ranid frogs currently is underway (Brown et al., unpublished data). Recognition of Philippine herpetological diversity has not simply been a process of splitting closely-related species; in fact, higher levels of taxonomic diversity are poorly understood in several key areas. The phylogenetic affinities of *Heosemys* (= "*Geomyda*") *leytensis* and *H. spinosa* are unclear; generic revision of these taxa may be required with on-going systematic studies (see Taylor, 1920b; Alcala, 1986; Timmerman and Auth, 1988; Buskirk, 1989; Iverson, 1992; Das, 1996a; Shaffer et al., 1997; Gonzales et al., 1997; McCord et al., 2000). A separate genus, *Coelognathus*, has been resurrected to accommodate Indo-Malayan ratsnakes (previously of the genus *Elaphe*; [Leviton, 1979]), including four Philippine taxa (Helfenberger, 2001). Finally, the discovery of a spectacular new species of frugivorous monitor lizard (Gaulke and Curio, 2001), presumably closely related to the Philippine endemic *Varanus olivaceus*, has captured the attention of herpetologists around the world. These studies indicate that an enormous amount of descriptive taxonomic work has yet to be conducted in the Philippines before we can adequately assert that the country's amphibian and reptilian species diversity is reasonably well known.

The types of data utilized by amphibian and reptilian taxonomists working in the Philippines have changed in some cases but have remained the same in many others. Although taxonomists are now distinguishing between species with DNA sequence divergence data (McGuire and Kiew, 2001; Brown et al., unpublished data), phylogenetic evidence such as a species' position in evolutionary trees (McGuire and Alcala, 2000; Brown and Guttman, in press), fixed allozyme differences (Brown, 1997; Brown and Guttman, in press), ecological differences (Brown et al., 2000a, 2000c) and behavioral differences (especially variation in acoustical advertisement signals of male frogs; Brown et al., 1997c, 1999a, 1999b; Brown and Guttman, in press), the majority of recent taxonomic papers have used morphological data in the form of character differences and comparisons of morphometric measurements or ratios of body proportions (Brown et al., 1997a, 1997b, 1997c, 1999a; Brown et al., 1995a, 1995b, 1999a, 1999b, 2000a, 2001).

Review of biogeographic studies of Philippine amphibians and reptiles

The first attempt at a biogeographic summarization of Philippine herpetofauna was Taylor's (1928) chapter in Dickerson's *Distribution of Life in the Philippines*. Taylor (1928) summarized the known species diversity at the time, plotted the distribution of the genera throughout the archipelago, and commented on possible dispersal routes. He also recognized the distinction between land-bridge (e.g., Palawan Aggregate Island Complex) and oceanic portions (the remainder) of the Philippines, although his distinction was inferred from distributional data from the fauna and not explicitly from a knowledge of channel depths or geological reconstructions. Taylor also noted the presence of several Sunda Shelf taxa in Palawan herpetofauna and the distribution of the more spectacular Philippine radiations (lizards of the genus *Brachymeles,* frogs of the genus *Platymantis,* and snakes of the genera *Oxyrhabdium*, *Cyclocorus,* and *Hologerrhum*) confined to the oceanic portions of the Philippines.

Later biogeographic summaries included papers by Inger (1954, 1999) on amphibians, Leviton's (1963) paper on snakes, Brown and Alcala's (1978) comments on gekkonids and their summary of the biogeography of the archipelago's herpetofauna (Brown and Alcala, 1970a). Brown (1997), Allison (1996), and Inger (1999) have summarized these data in the larger context of SE Asia and the SW Pacific. Most of these studies take similar approaches, namely the discussion of the zoogeographic relationships of the islands as indicated by calculation of faunal similarities (see also Brown and Alcala, 1986 and Ferner et al., 2001). All of these traditional summaries recognized most of the faunal subprovinces (five to seven distinct Pleistocene Aggregate Island Complexes) of Heaney (1985, 1986) as unique centers of biological endemism. Thus, Inger (1954), Leviton (1963) and Brown and Alcala (1970) all taxonomically recognized suites of endemic taxa on Luzon as separate from those of Mindanao or the Visayas (as embodied by the known herpetofauna of Negros; see Ferner et al, 2001) but fell short of acknowledging the importance of the lesser studied deep water islands of Mindoro, Sibuyan, Siquijor, Tablas + Romblon, Burias, islands of Batanes and the Babuyans, Camiguin, and Lubang. So, although endemic species were described from some of these islands (e.g., frogs and gecko endemics of Babuyans, Camiguin or Tablas; Brown and Alcala 1967, 1974, 1978) the explicit geological basis for the processes that may have led to these patterns of species endemism had not been emphasized. However, although Inger (1954), Leviton (1963), and Brown and Alcala (1967, 1970a, 1986) acknowledged channel depths as potential barriers to dispersal (deeper channels indicative of a reduced chance of landbridges having existed in the past), the underlying framework for recognition of all deep water islands as unique centers of biological endemism was not widely recognized until Heaney (1985, 1986) traced the underwater 120 m bathymetric contours throughout the Philippines (Fig. 5). This exercise explicitly illustrated Pleistocene sea shores at the end of last glacial episode (22-12,000 years before present) and the formation of enlarged aggregate island complexes by exposure of land positive connections between Philippine islands separated by less than 120 m (Fig. 5). The recognition of Pleistocene aggregate island complexes is the appropriate framework for appreciation of Philippine biodiversity on all levels (Heaney and Regalado, 1998), for it is the unique geological history of the islands that unites the evolutionary histories of all these islands' residents (review: Brown and Diesmos, this volume). Understanding of mid- to late-Pleistocene geology is the key to appreciating the distribution of life in the Philippines (Taylor, 1928; Inger, 1954; Leviton, 1963; Brown and Alcala, 1970; Heaney, 1985, 1986; see also Hall, 1996, 1998), and it is the key to formulating effective conservation strategies (Utzurrum, 1991; Oliver and Heaney, 1997; Heaney and Regalado, 1998). Additionally, interpretation of Philippine biodiversity in the context of Pleistocene geology is the best approach for formulating taxonomic and zoogeographic hypotheses (see below) for testing in a phylogenetic context (Brown, 1997; Brown et al., 2000c; McGuire and Alcala, 2000; McGuire and Kiew, 2001; Brown and Guttman, in press).

Finally, one last class of papers warrants consideration when reviewing Philippine biogeographical studies. These are faunal inventories, focused on singular sites or regions (i.e., Leviton, 1955; Alcala, 1956, 1958; Rabor and Alcala, 1959; Alviola et al., 1998; Smith, 1993a, 1993b; Ubaldo, 1999; Reis and Garong, 2001), particular mountains or mountain ranges (Alcala and Brown, 1955; Custodio, 1986; Alcala et al., 1995; Brown et al., 1996; 2000b; Diesmos, 1998), small islands (Brown and Alcala, 1963b, 1967, 1974; Ross and Lazell, 1991; Ross and Gonzales, 1992; Gaulke, 1993, 1999; Gaulke and Altenbach, 1994; Gaulke, 1994a, 1995a, 1996,1999), and large islands (Gaulke, 1994b, 2001a, 2001b, 2001c; Sison et al., 1995; Denzer et al. 1999; Ferner et al, 2001; Gaulke , 2001a, 2001b, 2001c). One important new study (a first of its kind in Philippine herpetology) addressed biogeographical relationships of Palawan using new data on late Quaternary vertebrate communities, including amphibians and reptiles (Reis and Garong, 2001). Further faunal inventories are badly needed to fill in gaps in distribution data left by earlier biogeographic summaries that conspicuously missed certain mountains or islands (Inger, 1954, 1999; Leviton, 1963; Brown and Alcala, 1970a). Published faunal papers are extremely important because of their role in educating the international community about Philippine biodiversity, and because they are an important source of baseline data for biogeographers, conservation biologists, ecologists, and systematists. Unfortunately, many important data that have been collected are unavailable in their unpublished form (government and non-government organization or private organization reports).

Phylogenetic and phylogeographic studies of Philippine amphibians and reptiles

The last several years have seen the advent of a new group of studies in Philippine herpetology. Brown (1997; Brown and Guttman, in press) conducted the first phylogenetic analysis of an endemic radiation of Philippine amphibians, and Brown et al. (2000c) and McGuire and Kiew (2001) published the first phylogenetic analyses of SE Asian reptiles with a significant proportion of their diversity represented in the Philippines. These three studies are significant in that they represent the first of their kind in Philippine herpetology and also because they strongly support interpretations of biogeographic patterns and routes of island colonization not previously suggested by data from birds and mammals. For example, Brown (1997) found that the Philippine *Rana signata* complex was composed of two major clades of frogs (Fig. 6a), one centered on the eastern Philippine island arc (Sulu-Mindanao-Leyte-Samar-Luzon) and one centered on the western island arc (Palawan-Buswanga-Mindoro; Brown, 1997; Brown and Guttman, in press), and that the stream frogs from Mindoro island were more closely related to those from Palawan and the Sunda Shelf than they were to the entire remainder of the oceanic portion of the Philippines (*contra* Inger, 1954, and Brown and Alcala, 1955, 1970a). In an additional phylogenetic study, Brown et al. (2000c; see Brown and Diesmos, in press, for review) conducted a phylogenetic analysis of the flap-legged geckos, genus *Luperosaurus* (half of which are Philippine endemics). This study showed evidence of two monophyletic clades, one with three non-Philippine species and the other containing the four Philippine species plus one species from northern Borneo. The position of the Bornean species, nested well within this second clade, suggested a re-invasion of Borneo from a Philippine source (probably the Sulu archipelago) following the initial radiation in the Philippine (Fig. 6b; Brown et al., 2000c; Brown and Diesmos, 2000).

McGuire and Kiew (2001; see also McGuire and Alcala, 2000) have demonstrated that flying lizards possess a much greater (10-12 lineages) species diversity in the Philippines than previously thought and that the endemic Palawan species is much more closely related to the true oceanic Philippine radiation than it is to Sunda Shelf species as suggested by earlier taxonomy (Fig. 7; *contra* Musters, 1983; Inger, 1983; Ross and Lazell, 1991). It is clear from McGuire and Kiew's (2000) analysis that Philippine *Draco* are derived from three separate invasions of the Philippines from the Sunda Shelf (Fig. 7).

Recent phylogenetic analyses of Old-world ratsnakes (Helfenberger, 2001) do not satisfactorily resolve the question of the monophyly of the Philippine supspecies of *Elaphe* (=*Coelognathus*) *erythrura* (*philippina, erythrura, manillensis*, and *psephenoura*; Leviton, 1979), but suggest that some Philippine lineages (designated as subspecies by Leviton, 1979) may, in fact, be valid species that are not each other's closest relatives. This study suggests that the relationships of the Philippine ratsnakes may be more interesting than previously thought, but that further studies, focussing specifically on the Philippine radiations, are needed. Recent phylogenetic analyses of crotaline snakes (Kraus et al., 1996; Malhotra and Thorpe, 1997, 2000) have included one or two species known from the Philippines. These analyses suggest the placement of Philippine radiations within larger groups of species but, as of yet, no exhaustive studies of Philippine radiations of snakes have been forthcoming.

One additional line of study (Emerson and Berrigan, 1993; Emerson, 1996; Emerson et al., 2000) contained several Philippine species of fanged frogs, genus *Limnonectes*. These studies indicate that the Philippine members of this genus are not a monophyletic group, but instead, most be-

long to a clade that also contains species from Sulawesi, suggesting a novel Philippines-Sulawesi connection (Evans et al., unpublished data) that have not been previously suggested by biogeographic studies of birds or mammals.

Phylogenetic analyses of several other groups of Philippine frogs are underway (Brown et al., unpublished data; Evans et al., unpublished data) and similar studies of selected Philippine lizard genera are also currently in progress (McGuire, Brown, and Diesmos, unpublished data). Results of these studies are preliminary but continue to suggest that the unique dispersal abilities of amphibians and reptiles, coupled with their finer scale patterns of differentiation on montane centers of endemism, have resulted in biogeographic patterns that are very different from those postulated traditionally for birds and mammals.

We believe that amphibians and reptiles represent excellent model systems for elucidating phylogenetic and interspecific phylogeographic patterns characteristic of lower relative dispersal abilities. As such, they should provide a powerful set of tools for distinguishing between hypotheses of vicariance from those of dispersal (characteristic of birds and volant mammals). Furthermore, future studies of Philippine amphibians and reptiles should provide a wealth of information to biogeographers on differing evolutionary processes that lead to their unique biogeographical patterns.

Ecological studies of Philippine amphibians and reptiles

Although there have been important ecological contributions to the literature in the last decade, a review of studies conducted in the past is necessary because so much of what we know is based on earlier work. It has become clear that amphibian and reptile community structure is strongly influenced by elevational gradients. The general results of workers utilizing elevational transect sampling regimes (Brown and Alcala, 1961; Brown et al., 1995b; 1996, 2000b; Diesmos, 1998; Ferner et al., 2001) suggest that species diversity decreases and endemicity increases with elevation (with a possible mid-elevation species bulge in diversity; Brown and Alcala, 1961; Diesmos, 1998). At present we lack the kind of fine scale information on elevational gradients that has been provided for mammals (e.g., Heaney and Rickart, 1990; Heaney et al., 1991; Rickart et al., 1991; but see Diesmos, 1998), and we have no detailed information (other than percent endemism) for community structure variation along elevational gradients on land-bridge versus oceanic islands. Such studies are greatly needed.

Habitats. The first sources of habitat preferences of Philippine amphibians and reptiles have been the descriptions of the habitats in which species were collected by taxonomists. Most of the taxonomic works of various workers (see Literature Cited; papers by Taylor, Brown, Alcala, Rabor, Inger, Leviton, Diesmos, Brown, McGuire, Gaulke, Ferner, and collaborators) mention specific microhabitats from which specimens were collected. From these works we can discern that important microhabitats for amphibians and reptiles collected in original forests include streamside microhabitats (on and under rocks, overhanging vegetation, debris on the banks, etc.), trees (on trunks, in branches, under bark, in canopies), epiphytes (aerial ferns, pandans, orchids, moss mats, suspended debris), litter and humus layers, upland moss accumulations, etc. A comprehensive synthesis of all that is known about habitat preferences would be very useful, but to date such a reference is still lacking. Fortunately, data on the microhabitat pref-

erences of many species are available in the publications listed in this section.

Several important papers of the past 15 years have expanded our knowledge of specific habitat preferences. Alcala and Brown (1987) discussed the habitat preferences of the unusual Philippine endemic frog, *Barbourula busuangensis*. Gonzales and Dans (1994) expounded on arboreal habitat preferences of certain lizards and amphibians on Mt. Makiling (see also Das and Charles, 1994; see also Torres, 1955), and Gaulke (1995b) reported on the unusual utilization of arboreal habitats by typhlopids (see also Taylor 1922e). Diesmos (1998) gave detailed descriptions of frog microhabitat preferences on Mt. Makiling and Mt. Banahao, S. Luzon, and Brown et al. (1996, 2000b) have presented habitat information on populations in the Zambales and Sierra Madre mountains. Recent survey work by Ferner et al. (2001) and Gaulke (2001a, 2001b, 2001c) includes significant new information on the habitat preferences of several poorly known species from Panay Island. A recent investigation into cave habitats (C. Dolino, unpublished data) should provide interesting new information on subterranean species' habitat preferences (see also Brown and Alcala, 2000). Brown and Diesmos (2000) discuss the paucity of information on canopy habitats in the Philippines (see also Lowman, and Nadkarni, 1995) and the lack of knowledge regarding the microhabitat preferences of geckos of the genera *Luperosaurus, Pseudogekko,* and *Ptychozoon* (see also Brown et al., 1997, 2000c). Auffenberg and Auffenberg (1988) have provided detailed habitat descriptions for 11 sympatric species of southern Luzon scincids, and Auffenberg (1988), Gaulke (1989a, 1992b), and Bennett (1999a, 1999b) provided some information on varanid lizard habitat preferences.

More detailed descriptions of species partitioning in heterogeneous habitats and elevational gradients are available in Alcala (1967, 1980), Custodio (1986), Auffenberg and

Auffenberg (1988), Brown et al. (1995b, 1996), Diesmos, 1998; Hampson (1999b), and Ledesma (1999). Additionally, Smith (1993a, 1993b), Alcala and Brown (1998), Bennett (1999a, 1999b), Hampson (1999a, 1999b, 2001), Ledesma (1999), and Gaulke (1992b; 1994a, 1995b, 1996, 1999), all contain other incidental habitat preference details for species involved. Brown et al. (2000a) utilized microhabitat preference differences to facilitate the recognition of a new species of frog from the Sierra Madre mountain range (*Rana tipanan*).

Reproduction and development. There has virtually been no progress in the study of developmental biology of Philippine species in the past 10 years and nearly all of what we know comes from the studies of earlier workers, most notably A. Alcala, in collaboration with Brown (Alcala and Rabor, 1957; Alcala, 1962; Alcala and Brown, 1955, 1956, 1982; Brown and Alcala 1982b; see also Brown and Reyes, 1956). Given the absence of recent studies directed at development and reproduction, we are left with an attempt to piece together what is known from these earlier studies, combined with an effort to summarize incidental observations from recent works. With the exception of limited developmental data on a few newly-described direct developing frogs of the genus *Platymantis* (Brown et al., 1997a, 1997b), there has been almost no new information published on developmental timing, reproductive effort, clutch size, or other basic life history characteristics since the time of Brown and Alcala's (1982b) review. For information on particular species, readers are referred to this work. In general, however, we can state that a high degree of life history variation is exhibited by Philippine Amphibia. For example, ranid frogs of the genus *Platymantis* all exhibit reliance on direct development (Alcala and Brown, 1955b, 1982; Alcala, 1962), while some groups (e.g., rhacophorids) possess a variety of reproductive tactics, from direct development (all *Philautus*) to the construction of arboreal foam nests coupled with aquatic development at later larval stages (*Rhacophorus* and *Polypedates*; Alcala, 1962; Alcala and Brown, 1982, 1994; Brown et al., 1997a). Most non-platymantine ranids, bufonids, microhylids, megophryids, and caecilians rely entirely on indirect aquatic development (Taylor, 1920a; Inger, 1954; Alcala and Brown, 1956; Alcala and Alcala, 1980; Brown and Alcala, 1982b) while some ranids undergo terrestrial development in nests near or away from water (Inger, 1954; Alcala, 1962; Brown and Alcala, 1982b; Inger et al., 1986; see also Brown and Iskandar, 2000). Finally, some life histories in the Philippines still completely unknown (i.e., *Barbourula busuangensis*; family Bombinatoridae; Taylor and Noble, 1924; Myers, 1943; Brown and Alcala, 1982b; Alcala and Brown, 1987; Ubaldo, 1999; Diesmos, Infante, Gee, and Brown, unpublished observations) provide opportunities for exciting future studies.

Auffenberg and Auffenberg (1989) provided a detailed descriptive study of reproductive patterns in 11 sympatric skink species from the Caramoan peninsula of southern Luzon. Their study described a striking level of diversity in clutch composition (egg number and size), parity mode (viviparous vs. oviparous), and seasonality (month of egg laying) of the reproductive effort in the species studied. It is clear from this study that we have barely scratched the surface of describing and understanding patterns in reproductive biology of Philippine scincid lizards. It is also quite clear that the spectacular diversity of reproductive patterns in Philippine scincids provides unparalleled opportunities for future research.

There is no comprehensive review of Philippine reptile reproductive modes available, but some information on seasonality and reproductive effort can be found in the papers of Alcala (1962; 1967), Alcala and Brown (1967), Brown and Alcala (1970c, 1982b), Auffenberg (1988), Auffenberg and Auffenberg (1988, 1989), and Gaulke (1989a, 1992a, 1992b). Additionally, it would be very useful to compile a reference for reproductive timing, clutch size, and incubation period for Philippine snakes and lizards. These areas are fertile grounds for future research.

Population biology. Population studies involving Philippine amphibians and reptiles have been traditionally limited (Alcala, 1955, 1967, 1970; Alcala and Brown, 1967; Brown and Alcala, 1961, 1963c, 1970c). The most in-depth focal study of a single Philippine species of reptiles is the work of Auffenberg (1988) on gray's monitor lizard, *Varanus olivaceus*, published just over a decade ago. Auffenberg (1988) provided information on reproduction, life history trait variation, behavior, population size and densities, age structure, natural longevity, and diet of *V. olivaceus*. Since that time, Gaulke (1989a, 1991a, 1992a, 1992b) has provided some of the same data for selected other subspecies of *Varanus salvator*, and Bennett, (1999a, 1999b) has supplemented our knowledge of diet, movement patterns, and parasite loads on Polillo island populations of *V. s. marmoratus* and *V. olivaceus*. There are no recent studies on the population biology of Philippine amphibians save for Afuang's (1994) study on the introduced species *Bufo marinus*.

Community ecology. There have been only a few studies of amphibian and reptile communities in the past (Brown and Alcala, 1961, 1963c; Custodio, 1986; Diesmos, 1998; Brown et al., 1996, 2000b; Ferner et al., 2001). Auffenberg and Auffenberg (1988) provided a detailed description of a community of 11 species of sympatric scincids on the Caramoan Peninsula of S. Luzon. Their analysis showed that scincid species diversity is positively associated with density of vegetation and structural complexity and that, among habitats, intact original forest was the habitat that supported the highest species diversity. In natural habitat gradients, such as the study area utilized by Auffenberg and Auffenberg (1988; from

intact virgin forest to beach side habitats), there exists a wide range of habitats, none of which was utilized by all species considered. In fact, physically similar and dissimilar species pairs (*Brachymeles samarensis-B. boulengeri, Mabuya multicarinata-M. multifasciata, Dasia grisia-Lipinia pulchella*) occupying similar habitats showed evidence of ecological replacement. Finally, Auffenberg and Auffenberg (1988) showed no evidence of prey selection or food as a limiting resource. They did show strong evidence of niche variation based on habitat preferences (variation in diet composition as a function of the available prey in different habitats), prey item shifts on populations inhabiting both forested and open habitats, and temporal variation in diet brought about by natural seasonality.

Recent studies include the investigation into lizard communities on Polillo Island by Ledesma (1999) and studies of frog communities by Hampson (1999b, 2001). These studies demonstrated that diversity is highest in forested habitats, or in boundary areas where forest and perianthropic/agricultural commensuals coexist. One of these studies demonstrated clearly that frog species density and richness increases with increasing distance into the forest away from agriculture (Hampson, 1999b, 2001).

Behavior. There have been virtually no behavioral studies in the history of Philippine herpetology, despite the enormous potential for research offered by Philippine populations of amphibians and reptiles. There have been significant behavioral observations of selected species, mostly having to do with antipredatory behavior and habitat preferences (Brown and Alcala, 1961, 1978; Brown et al., 2000a, 2000b), reproductive behavior (Alcala et al., 1987; Auffenberg, 1988; Gaulke, 1991a, 1992b; Auffenberg, 1988), diets (Reyes, 1957, 1968), or even spacing patterns and patterns of movement (Auffenberg, 1988; Auffenberg and Auffenberg, 1988; Bennett, 1999a, 1999b).

Recently, there have been an increasing number of papers containing information on communication in Philippine frogs (e.g., Alcala et al., 1986; Brzoska et al., 1986; Brown et al., 1997b, 1997c, 1999a, 1999b; Hampson, 1999b), and one in-depth study of the evolution of diversity of behavioral mate-recognition signals in the genus *Platymantis* currently is underway (Brown et al., unpublished data).

Conservation: a review of what we know and suspect

It is abundantly clear that amphibian and reptile populations in the Philippines are imperiled due to massive loss of their forested habitats (Brown and Alcala, 1986, 1994; Auffenberg, 1988; Diesmos, 1998; Gaulke, 1989b, 1992b, 1998; Hampson, 1999b; Brown et al., 2000b; Ferner et al., 2001; Heaney and Regalado, 1998; Heaney et al., 1999). Other anthropogenic factors include the indirect effects of industry and population growth, subsistence farming and habitat modification, and the direct causes of population declines due to over-hunting, and exploitation of populations for food and trade (Seale, 1917; Taylor, 1920b; Domantay, 1953; Punay, 1975; Ross, 1982; Bacolod, 1984, 1990; de Celis, 1995; Gaulke, 1998). Still, despite all other known causes of declines, we must accept that the removal of original forests or other forms of habitat loss remains the most pervasive cause of population decline in all forms of terrestrial Philippine wildlife (Brown and Alcala, 1986; Whitmore, 1984; Whitmore and Sayer, 1992; Primack and Lovejoy, 1995; Heaney and Mittermeier, 1997; Heaney and Regalado, 1998; Heaney et al., 1999). There can be no doubt that a significant percentage of habitat loss is related to government-sanctioned commercial industries (Heaney and Mittermeier, 1997; Heaney and Regalado, 1998; Heaney et al., 1999). Philippine forests continue to be felled at an alarming rate (Bawa et al., 1990; Whitmore 1990; Collins et al., 1991; Whitmore and Sayer,

1992; Primak and Lovejoy, 1995). Although logging in the Philippines has significantly slowed, it is clear that this trend is due primarily to the absence of significant stands of Philippine timber left to cut (Heaney et al., 1999) rather than as a result of government grassroots wildlife protection initiatives or government efforts to sustainably manage resources (Kummer, 1992; Sajise et al., 1996).

The last ten years have seen an increase in designation of protected areas and in public awareness of the need to preserve the habitats of endangered Philippine amphibians and reptiles (Brown and Alcala, 1986; de Celis, 1995; Sajise et al., 1996; DENR and UNEP, 1997; DENR and PALF, 1998; Heaney and Regalado, 1998; ECPF, 1998; Gaulke, 1998; Hicks, 2000; Tan, 2000). These advances in the potential for habitat protection are most encouraging (reviews: Heaney and Regalado; Heaney and Mittermeier, 1997; Heaney et al., 1999).

Conservation status of species. In recent years there has been a first genuine attempt to arrive at a consensus concerning the conservation status of amphibians and reptiles in the Philippines (Magbanua, 1991; Alcala and Custodio, 1995; Afuang and Gonzales, 1997; Gonzales et al., 1997; CI, FFI, and IUCN-SSC, 1999; Gaulke, 1998; Banks, 1999). In the past, international attention, concern, and attempts at regulation in the form of CITES or IUCN listings were limited to marine turtles (genera *Eretmochelys, Lepidochelys, Chelonia, Caretta,* and *Dermochelys*; see also de Celis, 1995), sailfin lizards (genus *Hydrosaurus*), a few freshwater turtles (genera *Heosemys, Pelochelys*), crocodiles (*Crocodylus porosus* and *C. mindorensis*; Ross, 1982; Trono, 1992; Ross and Alcala, 1993; Palma, 1993; Ortega et al., 1993; Regioniel, 1995), pythons (*Python reticulatus*), large water snakes (e.g., genera *Cerberus, Acrochordus, Laticauda, Hydrophis* and *Lapemis*), a few terrestrial snakes (e.g., genera *Naja*, *Elaphe*, *Stegonotus*, *Zoacys*; Alcala, 1986; Ross et al., 1987), and monitor lizards (*Varanus*; Gaulke, 1998)—those species presumably at risk due to an aggressive SE Asian leather trade (reviews: unpublished Sagip Wildlife Program list; Alcala, 1986; Gonzales et al., 1997; Erdelen, 1998; Gaulke, 1998; van Dijk et al., 2000). More recently, Alcala and Custodio (1995) and Afuang and Gonzales (1997; see also Banks, 1995, 1999) have begun an effort to address the conservation status of other, less noticeable species such as frogs (Afuang and Gonzales, 1997; CI, FFI, and IUCN-SSC, 1998; Banks, 1999; review: Hilton-Taylor, 2000). In contrast to many species status initiatives of the past that have argued for increased protection due to over-exploitation by humans, more recent projects (Alcala and Custodio, 1995; Gonzales et al., 1997; Banks, 1999) show that the majority of the newly listed species are considered threatened primarily by habitat loss, or are vulnerable as a consequence of limited geographical distributions.

The 1997 Wildlife Conservation Society of the Philippines *Philippine Red Data Book* (WCSP, 1997) represented the first attempt to arrive at a consensus as to the conservation status of Philippine amphibians and reptiles. Two amphibians and 10 reptiles considered globally threatened in the Philippines were included. Later, following the launching of the "Global Amphibian Campaign" (CI, FFI, and IUCN-SSC, 1999), Banks (1999) included an additional 32 species of Philippine amphibians in the 2000 *Red List of Threatened Species*. A new, comprehensive re-assessment of amphibian species' conservation status will soon be forthcoming (Diesmos et al., unpublished). We hope these efforts will result in increased protection of vulnerable populations, increased public awareness (Afuang et al., 2002), the designation of conservation priorities based on data (not politics), and increased use of conservation resources towards the study and protection of potentially threatened species.

Exploitation and consumption of amphibians and reptiles. There exists only a handful of studies documenting the exploitation of amphibian and reptile populations (as food sources, and for the leather and pet trades) in the Philippines. In general there are a few published reports that mention the use of amphibians and reptiles as food sources by indigenous groups (Villamor, 1990; Luxmoore and Groombridge, 1989; see also Gaulke, 1992b, 1998). We know that amphibians (rice field frogs of the genus *Rana* and fanged river frogs of the genus *Limnonectes*), reptiles (lizards of the genera *Hydrosaurus* and *Varanus*), and snakes, (i.e., genus *Python*) form an important part of the diet of many indigenous cultures in the Philippines (Lopez, 1976; Kikuchi, 1984; Griffin and Estioko-Griffin, 1985; Schult, 1991; review: Gaulke, 1989b). Road-side hawkers offering pythons and monitor lizards for sale are a common sight throughout the country (except in predominantly Muslim areas; *pers. obs.*).

However, many of the desired data (species identities, numbers of individuals harvested, seasonality of harvest, locations of primary harvests, percentage of the harvests that are subadults, sex of specimens harvested) are still lacking. We are in drastic need of these types of data in order to implement informed management decisions. Although leather and pet trade harvest and export were completely banned in 1994, the industry continues to thrive (Bacolod, 1984; 1990; Gaulke, 1989b, 1998) and is possibly growing (F. Yuwono, *pers. comm.*). Hides of Philippine reptiles continue to appear in overseas markets at the same time that rare and protected Philippine species are now increasingly advertised for sale at exorbitant prices on the internet (Brown, *pers. obs.*) as curiosities and "captive biological specimens" (= pets), reportedly, but doubtfully, bred in captivity in an attempt to "legalize" the selling of protected wildlife. We do know that unregulated exploitative harvests of sea snakes for skins have devastated rookeries in the Visayan sea (Bacolod, 1984; 1990), and that at present there are no specific laws in place to protect sea snakes from leather trade overexploitation (Gaulke, 1989b). The next decade will be a critical period in which the challenges of gaining information on these uses of amphibians and reptiles must be addressed in a meaningful fashion.

Some of the countries surrounding the Philippines have made efforts to monitor, regulate, and sustainably manage reptile harvests (Erdelen, 1998; van Dijk et al., 2000), and it is now time to begin a dialogue on the Philippines' own response to these growing industries. Gaulke (1998) recommended the implementation of regionally-oriented wildlife management plans which include protection of certain areas, but with legal trapping based on quotas and the principles of sustainable yield in others. This proposal is worthy of consideration because of the manner in which it may benefit both the animals and the local communities. In general, regulated, sustainable harvest of protected species is more desirable than unfettered, unregulated, unmonitored rampant illegal exploitation (Webb and Vardon, 1998; Shine et al., 1998; Erdelen, 1998; Webb and Vardon, 1998). We expect that some *Varanus, Acrochordus, Hydrophis, Laticauda, Naja* and *Python* populations can be harvested at sustainable levels once data are available to indicate the appropriate levels and harvest times. Data needed include the number of individuals that can be sustainably harvested from a population, when the appropriate (non-breeding) harvest season should occur, and which populations may be sustainably culled versus which must be allowed to recover unmolested.

Illegal collectors view black market trade as a nonrenewable resource that is best exploited as quickly as possible in order to accrue as much income as possible before their illegal activities are exposed. In contrast, legally-registered traders and leather merchants who invest in the monitoring of their resources tend to protect and guard their sources (see papers in Erdelen, 1998, e.g., Yuwono, 1998) and prevent

over-harvesting in order to insure future yields and their own livelihood. Finally, legal monitoring of reptile harvests would provide a great many badly-needed data for policy makers and wildlife biologists. With information on yields, size of harvests, percentages of each sex, and harvest locations (e.g., Shine et al., 1998), informed, biologically sound recommendations, and management decisions could be made to insure the continued survival of economically important species (Yuwono, 1998; Melisch, 1998; Gaulke, 1998). In the absence of such data, we are left with ignorance and forced to proceed from guesswork, while an unregulated black market in Philippines amphibians and reptiles continues to thrive.

Introduction of exotic species and the threat they pose. Recent survey work by Diesmos (1998; unpublished data; see also Diesmos, 2000, 2001) has augmented data on Asian and American species introduced into the Philippines. We now know that in addition to the Sunda Shelf species *Rana erythraea* (Brown and Alcala, 1970c; Alcala, 1986), middle American cane toads (*Bufo marinus*; Alcala, 1986; Afuang, 1994), Taiwanese bullfrogs (*Hoplobatrachus rugulosus*; Diesmos, 1998; Alcala and Brown, 1998), and American bullfrogs (*Rana catesbiana*; Inovejas and Vergara, 1985), have established breeding populations in the Philippines. All of these species have rapidly spread (Diesmos and Brown, *pers. obs.*) from the points of their original introductions. The rapid generation time, voracious dietary habits, and invasive abilities of the latter three species suggest that they represent serious threats to the communities and habitats they currently inhabit and that syntopic populations of Philippine endemics may soon be seriously threatened by these introductions. Basic documentary studies (Heyer et al., 1994) on the spread of these non-native species and their behavioral interactions with Philippine species are badly needed to document and, hopefully, stem the spread of potentially catastrophic invasions.

Legal issues, restrictions, and research permits

Gaulke (1998) reviewed the laws (or absence thereof) governing the exploitation and harvest of monitor lizards, pythons, sea snakes, and file snakes in the Philippines. The passage of Executive Order 247 of the Ramos administration (la Viña et al., 1997) and the recent Wildlife Bill under the Macapagal-Arroyo administration are both new attempts to protect Philippine wildlife and natural resources, including reptiles and amphibians. These efforts are generally encouraging in that they demonstrate an increased concern for the welfare of Philippine wildlife. Unfortunately, the co-occurring legal restrictions on the activities of research scientists and wildlife biologists have seriously crippled biodiversity research.

At present we see the absence of a clear cut distinction between academic/research and commercially-oriented activities (La Viña et al., 1997) as a policy in need of revision. Without such a distinction, EO 247 will continue to cripple biodiversity studies, despite its good intentions. One negative impact of the passage of EO 247 has been the manner in which it has contributed to an incorrect public perception of biologists as somehow akin to commercial exploiters of the environment ("bioprospectors"). Executive Order 247 was designed to protect wildlife and the Philippine environment from commercially exploitative enterprises such as large scale commercial harvesting of wildlife (i.e., butterfly and orchid collecting for lucrative overseas markets, unregulated pet trade harvests, or large-scale collecting of snakes, lizards, and turtles for shell and leather trades), commercial pharmaceutical extraction of potentially valuable plant extracts, commercial logging, or any other activity on the part of persons or groups who would profit from the sale or copyright of Philippine biological resources (La Viña et al., 1997). Unfortunately, the same restrictions that were developed to monitor and regulate commercial exploitation of biological resources now also apply to biodiversity researchers and field biologists.

Although biologists must also collect and preserve biological specimens as part of biodiversity studies, they do not use these preserved animals and plants for personal or commercial gain but, instead, deposit them in internationally accredited institutions such as the National Museum of the Philippines (Simmons, 1987; Reynolds et al., 1994; Resetar and Voris, 1997) where they become part of the public record and natural heritage of the nation rather than contribute to money-making enterprises. The philosophical, ethical, and practical differences between the activities of non-profit, scientific biologists and for-profit, commercial bioprospectors are beyond the scope of this paper, but numerous obvious distinctions are immediately apparent. The need for regulatory legislation that also distinguishes between the activities of commercial bioprospectors and research biologists should be equally apparent. Finally, although we are aware that it was not intended as such, the current implementation of EO 247 amounts to a policy of economic discrimination against university students and junior scientists. This is because the seemingly endless lists of legal requirements make it prohibitively expensive and nearly impossible for university students and biologists working with modest budgets to obtain legitimate research permits.

We suspect that most of the present bureaucratic restrictions on biologists stem from the understandable yet uninformed opinion of policymakers that the best way to preserve Philippine wildlife is to prevent any killing of animals, even in the name of identifying and cataloging the country's biodiversity. It is difficult to find fault with these sentiments because we too disdain the needless killing of animals. However, the total prevention of responsible faunal collecting efforts as part of legitimate biodiversity studies is misdirected. First, there is simply no substitute for vouchered locality data for mapping distributions of species (Reynolds et al., 1994). Second, there is no evidence to support the notion that responsible scientific collecting has negative impacts on natural populations (Hedges and Thomas, 1991; Goodman and Lanyon, 1994; Stuebing, 1998). Finally, the absolute need for the data generated by biologists' efforts is undeniable. Truly effective conservation programs rely heavily on quality museum collections (Hawksworth and Mound, 1991; Hedges and Thomas, 1991) and the importance of systematic collections for conservation efforts is immense (Hoagland, 1989; Foster, 1982; Nielsen and West, 1994; Savage, 1995; David, 1996; Leh, 1996; Resetar and Voris, 1997; Shaffer et al., 1998; Ponder et al., 2001). This is because the baseline data contained in museum collections form a disproportionately large percentage of material in databasing efforts, conservation priority-setting activities, and overall conservation of biological resources (e.g., Conservation International's recent Philippine Priority-Setting Workshops—based almost entirely on museum collection data).

At present, some informal discussions have been initiated regarding the establishment of a new Philippine government permitting system that would distinguish between commercial efforts and academic or university-based research, and we are very hopeful that relief will be forthcoming. However, we must stress that current government policies need to be revised so that they *promote, facilitate,* and *encourage* responsible research on biodiversity rather than strongly inhibit, restrict, or prevent it. Without such changes, current laws will probably continue to promote local paranoia, eventually causing unproductive rifts between the government and non-government, university, local, and scientific communities. The result of such rifts can only be that Philippine environment, Filipino biologists, and the biodiversity of this country will continue to suffer.

Comparisons with neighboring countries

A superficial look at the herpetological literature from surrounding SE Asian and SW Pacific countries reveals that trends in Philippine herpetology fit into the context of a great regional increase of knowledge during the past half century. Due to the inequality of progress in all regions, wide-scale comparisons are impossible at the present time. Nevertheless, some valuable comparisons can be made (and hopefully, are heuristic). For example, while estimates of numbers of amphibian species in the Philippines have increased (from 55 to 105 species; Inger, 1954; Alcala, 1986; Alcala and Brown, 1998; Brown and Diesmos, in press), so too have species estimates increased significantly on the island of Borneo (from 92 to 138 recognized species; Inger, 1966; Frost, 1985, 2000; Duellman, 1993; Inger and Tan, 1996a, 1996b; Inger, 1999). In fact similar trends can be seen on the islands of Java, Sumatra, and Bali (Iskandar, 1998; Frost, 1985; Duellman, 1993; Inger, 1999; Iskandar and Colijn, 2000), Sulawesi (Frost, 1985; Duellman, 1993; Iskandar and Tjan, 1996), New Guinea, and the Solomon-Bismark archipelagos (Frost, 1985, 2000; Duellman, 1993; Allison, 1996; Brown, 1997; Inger, 1999; Allison and Kraus, 2001). Similarly, though several comprehensive biodiversity projects are still in progress, we are aware that estimates of snake, turtle, and lizard diversity have substantially increased (Welch, 1988; Welch et al., 1990; Zhao et al., 1988, 2000; Keng and Tat-Mong, 1989; Matsui et al., 1989; Cox, 1991; Iverson, 1992; Lim and Lim, 1992; Zhao and Adler, 1993; Das, 1995, 1996b, 1998; David and Vogel, 1996; Dutta and Manamendra-Arachichi, 1996; Inger and Tan, 1996a, 1996b; Inger and Stuebing, 1989, 1997 Chou and Lin, 1997; Manthey and Grossman, 1997; Cox et al., 1998; da Silva, 1998; Chan-ard et al., 1999; Inger, 1999; Liat and Das, 1999; McDiarmid et al., 1999; Ota, 1999; Stuebing and Inger, 1999; Iskandar, 2000). Although a comprehensive review of all types of studies involving amphibians and reptiles throughout Asia and the Pacific is beyond the scope of this paper, our general impression is that the same trends that we have witnessed in the Philippines, specifically an explosion in the types of studies and dramatic increase in biodiversity and conservation, have occurred throughout SE Asia. As such, progress in Philippine herpetology fits into a broader context of the overall trends seen in SE Asia: dramatic increases in estimated numbers of species, increased understanding of natural history, systematics, biogeography, and ecology coupled with a drastic need for more information and conservation initiatives.

Future directions: the decade to come

Targets: species, sites, and kinds of studies. In this section we attempt to identify substantive gaps or research topics in need of study in Philippine herpetology.

In general, there has been more recent taxonomic work in amphibians than in reptiles. Accordingly, while we know of numerous undescribed Philippine amphibians, we suspect that far more numerous species of reptiles await discovery. There is a great need for comprehensive reviews of Philippine lizards and snakes within the context of modern species concepts.

Additionally, numerous regions of the Philippines cry out for faunal surveys. In a recent faunal survey in Aurora Memorial Natural Park, Brown et al. (2000b) stressed the need for exhaustive herpetological surveys throughout the Sierra Madre range. Similarly, while Brown et al. (1996) have provided a preliminary account of herpetological communities in the Zambales, their survey was conducted immediately following the eruption of Mt. Pinatubo, and so we suggest that further surveys are needed, especially if we are to gain an adequate

knowledge of amphibian diversity in this isolated mountain range (see comments by Diesmos, 1998). Recent work in the Central Cordillera (Heaney et al., 2000; Diesmos, Brown, Gee, unpublished data) should provide an important preliminary update towards the assessment of this mountain range's herpetological fauna, but other localities, specifically in the southern portions of the Cordillera, are in equally critical need of similar studies.

Likewise, the mountains of the Bicol Peninsula each deserve intensive survey efforts (see Brown et al., 2002). Outside of Luzon, numerous other areas require basic survey efforts. These include southeastern Mindoro, all of Samar and Leyte (but see Gaulke, 1994b; Deuzer et al., 1999), high elevation habitats of Mindanao (but see Rabor and Alcala, 1959; Smith, 1993a, 1993b), and numerous smaller islands including (but not limited to) Masbate (but see Gaulke, and Altenbach, 1994c), Sibuyan, Lubang, Burias, Siquijor, Camiguin, Maestro de Campo, Semirara, the Batanes and Babuyans, all of Palawan, Busuanga, Coron (But see Gaulke, 1999), and the Sulu archipelago (but see Gaulke, 1993, 1994a, 1995a, 1996).

Finally, basic population biology, behavioral, and reproductive biology studies are needed for numerous species believed to be threatened by activities of humans. It is only through the careful collection of basic population and demographic data that we will be able to make sound management recommendations. And it is only through the collection of basic data on the use of amphibians and reptiles by commercial and indigenous harvesters that we will be able to assess which populations are being most heavily exploited.

Publications and survey data. One final lesson from our experiences over the past decade that cannot be stressed too often or too fervently is the need to encourage students, government, non-government, and even contracted workers to publish the results of their studies. The amount of critically important unpublished data that we are aware of is staggering. If the information contained in non-government organizations' and university students' unpublished reports was now available to wildlife managers, conservation biologists, biodiversity specialists, and biogeographers, the state of Philippine herpetology would be markedly different than it is at present. In truth, unpublished survey data may do more harm than good because the tendency is for permitting authorities to discourage reinvestigations of previously-surveyed areas. Thus, unpublished data not only are unjustified (why collect data if they will not be put to use as part of the public record?), but they actually have a negative impact by barring later workers access to the same regions (Crombie, 1992).

Similarly, rushed or non-exhaustive, or even the burgeoningly popular "rapid assessment" surveys can often do more harm than good. In this instance, "a little" is not "better than nothing at all" if the results are that permitting authorities deny permission to conduct follow up surveys because the perception is that the work has already been completed. No amount of reanalysis of insufficient data will have positive or even illustrative results. We agree with Crombie's recent comment that "...considerable money and effort are being expended on analyzing [herpetological species] distribution information when the data base is so paltry that it scarcely warrants the exercise" (Crombie, 1992:594).

Field work. As suggested by Crombie's quote at the beginning of this paper, we believe the degree to which basic reliable distribution data are lacking and badly needed cannot be stressed too often. Unfortunately, the public disinterest, financial difficulties, and bureaucratic obstacles faced by any budding field research program in herpetology at the present day in the Philippines can be overwhelming. To students finding themselves in these or similar situations we wish to offer our encouragement and assistance wherever possible. This is because a comprehensive, careful, and well-orchestrated (and published in a timely fashion) field survey of even a single forested site makes a major contribution to our collective knowledge of Philippine herpetology. Simple "rice and beans" (Crombie, 1992) or "bean-counting" (A. Malliari, *pers. comm.*) field exercises can drastically change the way we view complex topics such as the influence of geological processes and marine barriers to gene flow on speciation and the composition of faunal communities, the effects of elevation on species abundance and distribution patterns, and overall zoogeographical relationships of particular islands (Brown et al., 1996; 2000b; Diesmos, 1998; Ferner et al., 2001). For all of these data, and the paradigm-altering conclusions that have been, and continue to be drawn from them, there is no substitute for reliable distribution data based on specimens deposited in accredited natural history museums.

Integration. We anticipate that the next decade will see a genuine effort to integrate recent efforts of taxonomists, systematists, biogeographers, and conservationists. Our review of the literature suggests that current herpetology in the Philippines is in a final stage of discovery. This descriptive, piece-meal process will no doubt culminate in the availability of an enormous amount of data available for reviews, syntheses of taxonomy and distribution, large scale biogeographic studies, and meta-analyses of ecological studies. Ecological, behavioral, and population studies will no doubt contribute to conservation if they can be integrated into larger synthetic analyses within the context of known history. Recent comprehensive studies of taxonomy, systematics, and the numerous factors affecting species distributions will no doubt have broad implications for conservation and management decisions. Integrating these studies and formulating and implementing policies on the basis of sound biology (instead of politics) will be a major challenge for the next decade's biologists, students, and policy makers.

Collaboration. It is instructive to note that Philippine herpetology has a rich recent history of international collaborative efforts. In particular, the development of Philippine herpetology since the 1950s has relied, at least in part, on foreign support. It has been this cooperation and partnership of scientists from several different countries that has produced the most remarkable discoveries and advances in Philippine herpetology. This tradition has taken the form of financial support for field research, advice, guidance, encouragement, and facilitation of academic studies abroad. We feel this history provides us with an important lesson. Biodiversity studies by both Filipinos and foreigners should be conducted in collaboration with Filipinos at all levels—government, university, municipality and the barangay. Our experience has shown that it is in the best interest of everyone for researchers coming to the Philippines to collaborate closely with Philippine scientists and local community representatives. There is a great deal to be shared and

learned through partnerships with local communities. In one sense, local communities are the most important guardians of the remaining forests; as such, it is in everyone's best interest that scientists, government officials, regional resource managers, and local indigenous peoples' organizations work together. The most productive research programs of recent history have all been collaborative efforts. By combining efforts, Filipinos and non-Filipinos have been able to achieve much more in collaboration than could have been possible as part of separate research programs. We are greatly encouraged by the fact that recent collaborative research efforts and conservation programs are now being led by Filipino biologists.

The last decade and the next generation of Philippine herpetologists. This last decade has left us with a growing sense of urgency and the ever-increasing need to involve and encourage Filipino students to participate in the study of their country's amphibians and reptiles. In particular, we are encouraged by the recent emergence of numerous women in Philippine herpetology and we support their interest and involvement in a field of science traditionally dominated by a few male personalities. We are intrigued to imagine who will constitute the next generation of Philippine herpetologists and we wish to encourage all interested students to pursue herpetology as a field of study, especially in the field, even (and perhaps especially) as represented by the populations in their backyards. It is our hope that the next generation of Philippine herpetologists can learn from our trials, our accomplishments, and our mistakes, and continue to work towards new, ever-enlightening conclusions. We hope students will find inspiration from past achievements in the field to realize their own power to make significant contributions, change the future's understanding, and increase the next generations' appreciation of the spectacular diversity, remarkable uniqueness, and intriguing natural history of amphibians and reptiles in the Philippines.

Acknowledgments

We are unable to express our gratitude towards all of the individuals, too numerous to list here, who have supported our efforts over the past decade. To these individuals, we offer our thanks and compliments. In particular, we thank our families for their patience and support and W. Brown, L. Heaney, R. Inger, J. McGuire, R. Crombie, A. Ross, A. Leviton, J. Ferner, N. Malliari, R. Fernandez, and R. Sison for helpful discussions regarding Philippine amphibian and reptile diversity. Constructive reviews of the manuscript were provided by M. Leonida, L. Heaney, J. Weghorst and an anonymous reviewer.

We dedicate this paper to Walter C. Brown in thanks for the inspiration, encouragement, and support he has provided to each of us.

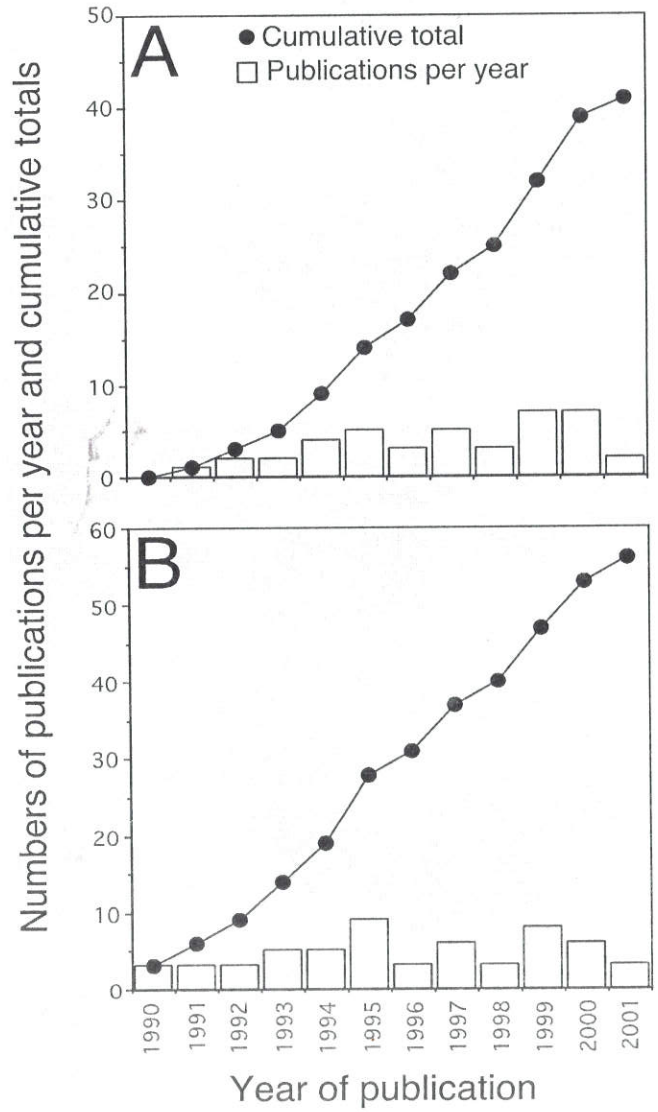
Table 1. List of amphibian species described since 1990.

Species	Family	Authority	Distribution
Kaloula kokacii	Microhylidae	Ross and Gonzales, 1992	Catanduanes Isl.
Philautus poecilus	Rhacophoridae	Brown and Alcala, 1994	Mt. Hilong-hilong, Mindanao Isl.
Philautus surrufus	Rhacophoridae	Brown and Alcala, 1994	Dapitan Peak, Mindanao Isl.
Platymantis panayensis	Ranidae	Brown, Brown, and Alcala, 1997	Mt. Madja-as, Panay Isl.
Platymantis isarog	Ranidae	Brown, Brown, Alcala, and Frost, 1997	Mt. Isarog, Luzon Isl.
Platymantis mimulus	Ranidae	Brown, Alcala, and Diesmos, 1997	Mt. Maquiling, Luzon Isl.
Platymantis rabori	Ranidae	Brown, Alcala, Diesmos, and Alcala, 1997	Cantaub, Bohol Isl.
Platymantis negrosensis	Ranidae	Brown, Alcala, Diesmos, and Alcala, 1997	Cuernos de Negros, Negros Isl.
Platymantis luzonensis	Ranidae	Brown, Alcala, Diesmos, and Alcala, 1997	Mt. Maquiling, Luzon Isl.
Platymantis banahao	Ranidae	Brown, Alcala, Diesmos, and Alcala, 1997	Mt. Banahao, Luzon Isl.
Platymantis pygmaeus	Ranidae	Alcala, Brown, and Diesmos, 1998	Sierra Madre mountains, Luzon Isl.
Platymantis naomiae	Ranidae	Alcala, Brown, and Diesmos, 1998	Mt. Banahao, Luzon Is.
Platymantis sierramadrensis	Ranidae	Brown, Alcala, Ong, and Diesmos, 1999	Sierra Madre mountains, Luzon Isl.
Platymantis cagayanensis	Ranidae	Brown, Alcala, and Diesmos, 1999	Central Cordillera mountains, Luzon Isl.
Platymantis taylori	Ranidae	Brown, Alcala, and Diesmos, 1999	Sierra Madre mountains, Luzon Isl.
Platymantis pseudodorsalis	Ranidae	Brown, Alcala, and Diesmos, 1999	Mt. Banahao, Luzon Isl.
Platymantis indeprensus	Ranidae	Brown, Alcala, and Diesmos, 1999	Mts. Banahao and San Cristobal, Luzon Isl.
Rana tipanan	Ranidae	Brown, McGuire, and Diesmos, 2000	Sierra Madre mountains, Luzon Isl.
Rana new species	Ranidae	Brown and Guttman, in press	Mindoro Isl.
Kaloula new species	Microhylidae	Diesmos, Brown, and Alcala, in review	Southern Luzon Isl.

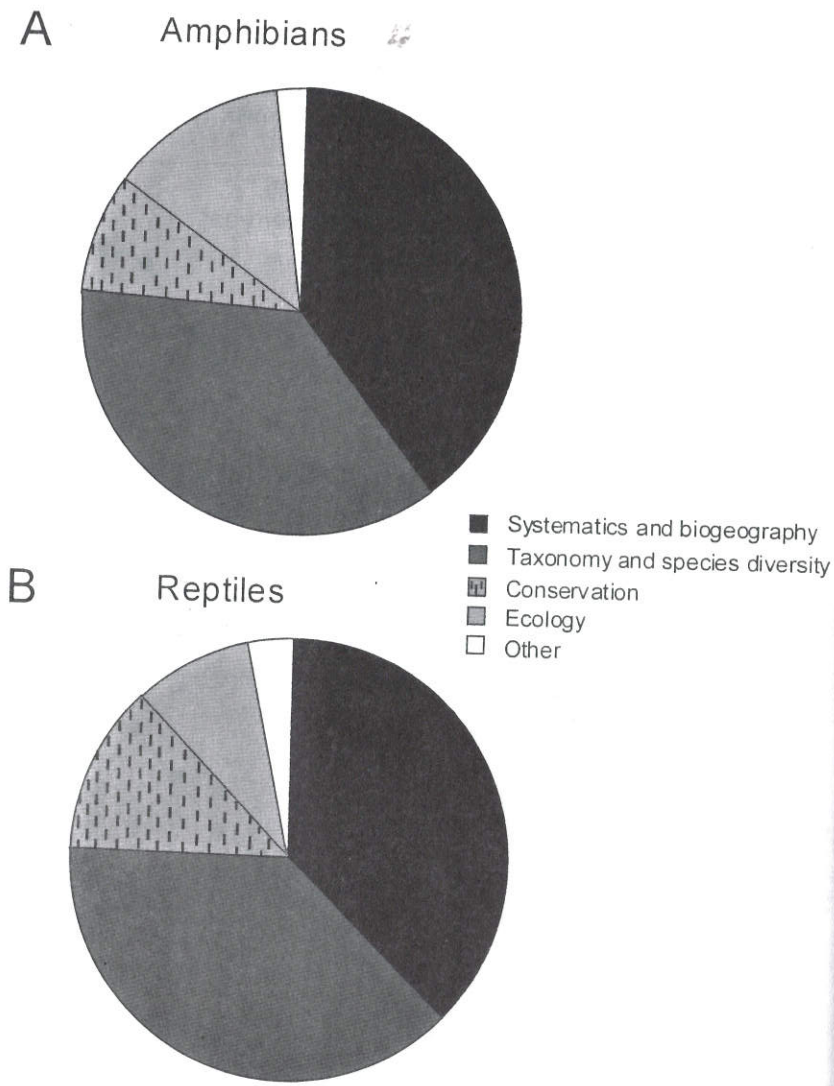
Table 2. List of reptilian taxa described since 1989.

Species	Family	Authority	Distribution
Lepidodactylus balioburius	Gekkonidae	Ota and Crombie, 1989	Batan Isl.
Draco jareckii	Agamidae	Lazell, 1992	Batan Isl.
Typhlops castanotus	Typhlopidae	Wynn and Leviton, 1993	Inampulugan Isl.
Typhlops collaris	Typhlopidae	Wynn and Leviton, 1993	Mt. Anuling, Luzon Isl.
Lycodon alcalai	Colubridae	Ota and Ross, 1994	Batan Isl.
Lycodon bibonius	Colubridae	Ota and Ross, 1994	Camiguin Isl.
Lycodon chrysoprateros	Colubridae	Ota and Ross, 1994	Dalupiri Isl.
Lycodon solivagus	Colubridae	Ota and Ross, 1994	Central Cordillera mountains, Luzon Isl.
Ahaetulla prasina suluensis	Colubridae	Gaulke, 1994	Tawitawi island group, Sulu archipelago
Sphenomorphus kitangladensis	Scincidae	Brown, 1995	Mt. Kitanglad, Mindanao Isl.
Sphenomorphus knollmanae	Scincidae	Brown, Ferner, and Ruedas, 1995	Mt. Isarog, Luzon Isl.
Brachymeles minimus	Scincidae	Brown and E. Alcala, 1995	Catanduanes Isl.
Parvoscincus sisoni	Scincidae	Ferner, Brown, and Greer, 1997	Mt. Madja-as, Panay Isl.
Sphenomorphus tagapayo	Scincidae	Brown, McGuire, Ferner, and Alcala, 1999	Mt. Maaling-aling, Luzon Isl.
Pseudorabdion talonuran	Colubridae	Brown, Leviton, and Sison, 1999	Mt. Madja-as, Panay Isl.
Draco palawanensis	Agamidae	McGuire and Alcala, 2000	Palawan Isl.
Hologerrhum dermali	Colubridae	Brown, Leviton, Ferner, and Sison, 2001	Mt. Madja-as, Panay Isl.
Lycodon fausti	Colubridae	Gaulke, 2002	NW Panay Isl.
Varanus mabitang	Varanidae	Gaulke and Curio, 2001	NW Panay Isl.

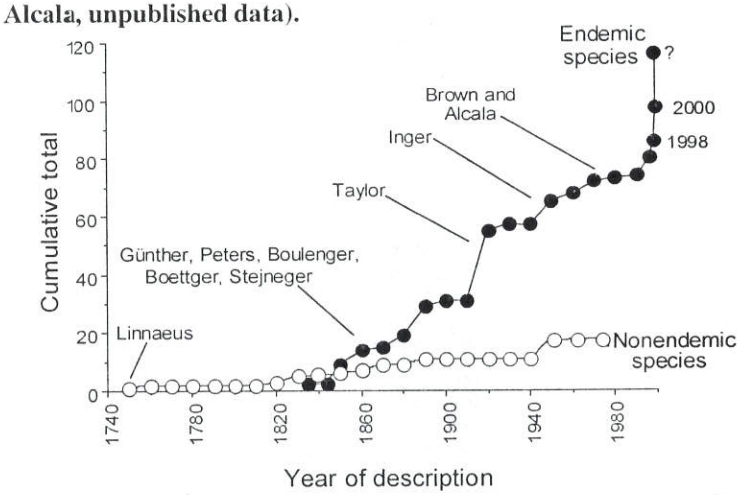
(Fig. 1) The relationship between the number of articles published per year (unshaded bars), the cummulative total of published articles for the past decade (shaded circles) and the year of publication for amphibian (A) and reptiles (B). Note: some articles were counted twice, as in the case where a publication addressed both amphibians and reptiles (e.g., Brown et al., 1996, Ferner et al., 2001; Gaulke, 1996, 1999) or taxonomy and systematics (Brown, 1997).



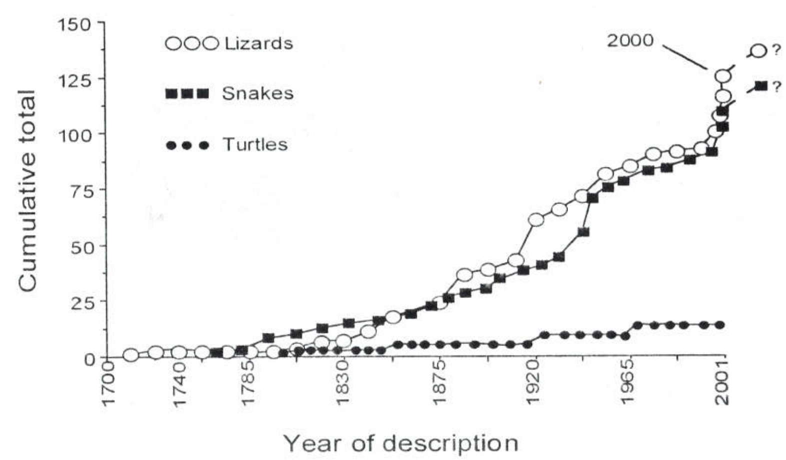
(Fig. 2) Composition of the last decade's literature on Philippine amphibians (A) and reptiles (B).



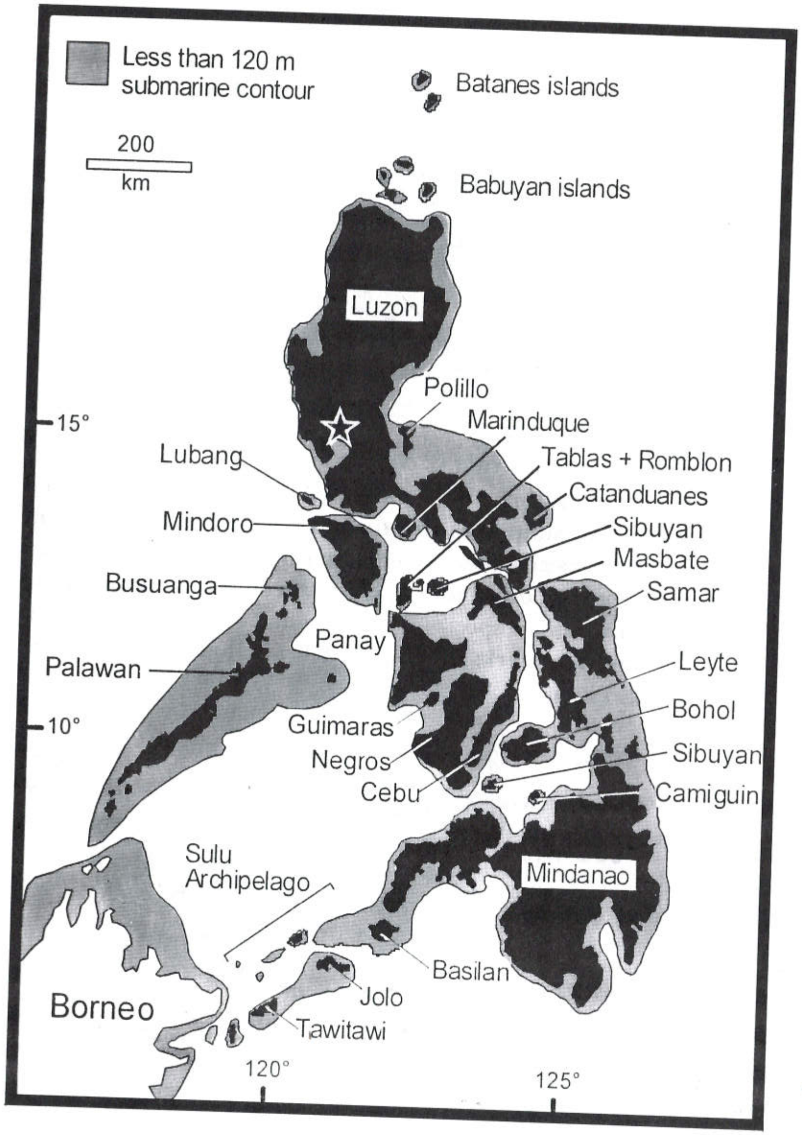
(Fig. 3) The relationship between the cumulative total number of amphibian species in the Philippines and the year of description. Note the dramatic increase in rate of descriptions in the past decade. The final point on this line (indicated with question mark) is the estimated number of new species awaiting description (Diesmos, Brown, and Alcala, unpublished data).



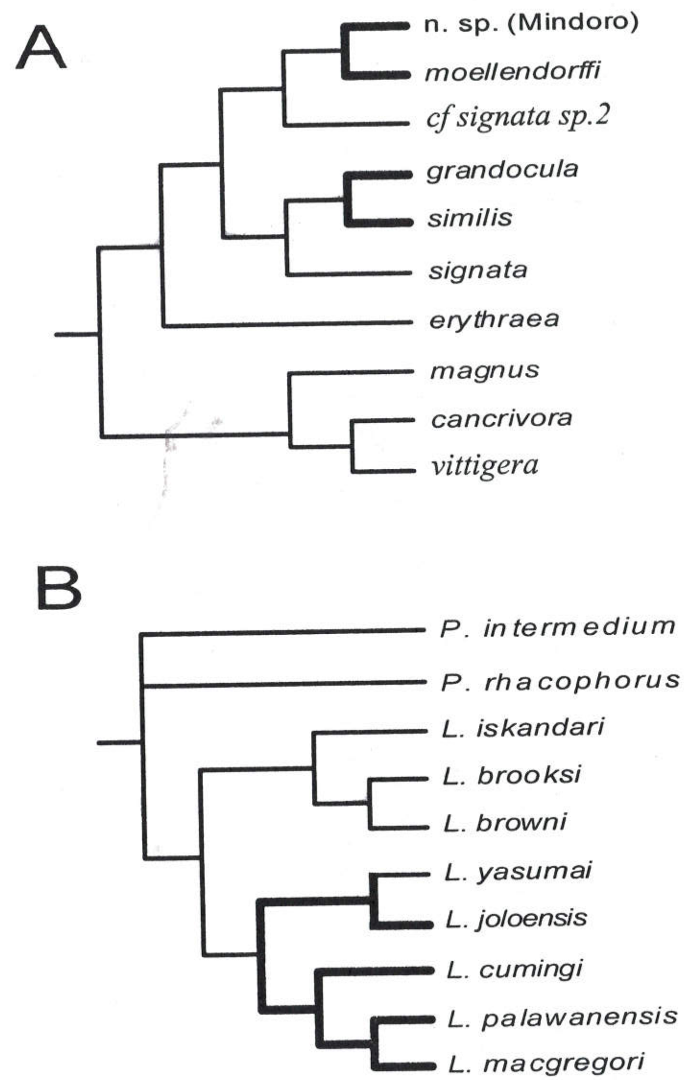
(Fig. 4) The relationship between the cumulative total number of reptile species in the Philippines and the year of description. For simplicity, only total species counts (endemic + non-endemic) are shown, and these are broken down into snakes, lizards, and turtles. Species diversity in crocodilian species is n = 2. Final species counts (indicated with question marks) are estimated numbers of new species awaiting description.



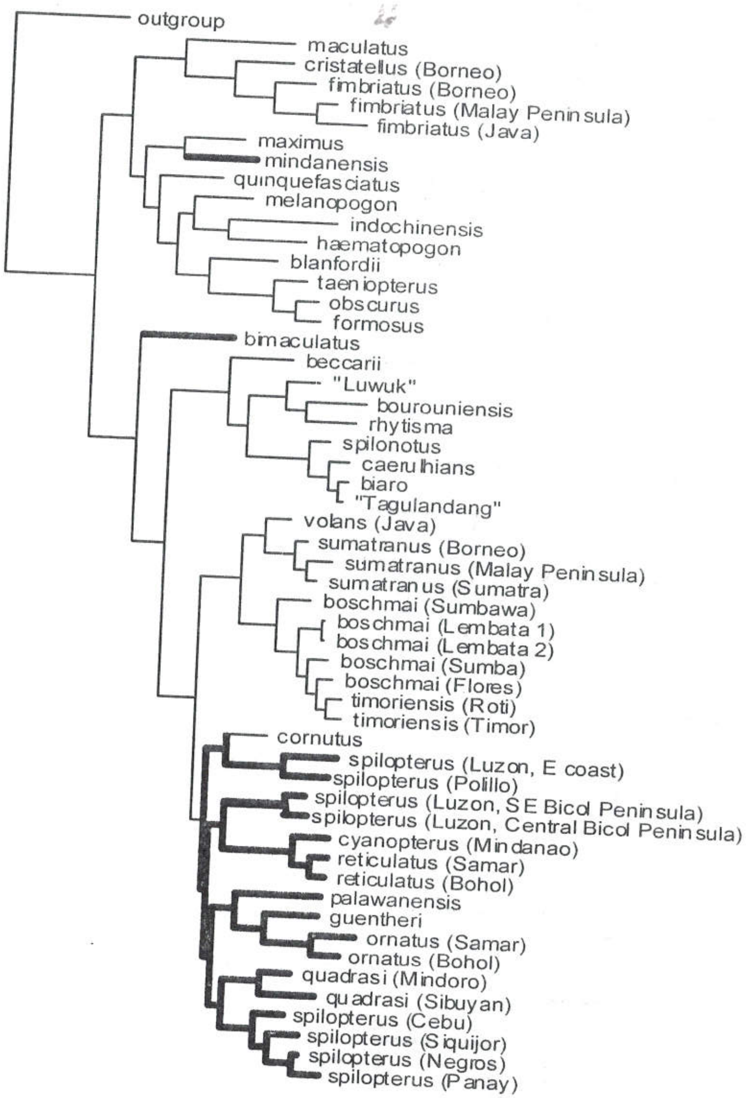
(Fig. 5) Formation of geological componentry of the Philippines: the major Pleistocene aggregate island complexes as delineated by the 120 underwater bathymetric contour and known mid- to late-Pleistocene sea level reductions (following Heaney, 1985, 1986).



(Fig. 6) The preferred phylogenetic hypotheses for the *Rana signata* complex of Philippine and Bornean stream frogs (A: Brown, 1997; Brown and Guttman, in press; bold terminal branches indicate Philippine *R. signata* complex species) and the preferred phylogenetic tree for the genus *Luperosaurus* (B: Brown et al., 2000c; bold terminal branches indicate Philippine species).



(Fig. 7) The preferred phylogenetic hypothesis for flying lizards of the genus *Draco* (McGuire and Kiew, 2001). Bold terminal branches indicate Philippine species.



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A DECADE OF RESEARCH ON PHILIPPINE MAMMALS: PROGRESS AND CHALLENGES

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ABSTRACT

The mammal fauna of the Philippines is exceptionally rich in endemic mammals, and also has a very high proportion of endangered species. Research during the period 1990 to 2000 has resulted in an improved understanding of the basic systematics of the 172 native land-mammal species known to be present. Some of the recently-discovered species have been formally described (but others have not), and a few identification keys are now available (but more are badly needed). Studies of comparative morphology, karyotypes, and protein allozymes have yielded information on phylogenetic relationships, but this topic remains poorly investigated. Published faunal surveys have produced the first comprehensive inventories in the country yielding much crucial information on ecology and biogeography and the material for taxonomic studies, but many more are needed, and many unpublished surveys are not available.

Biogeographic analyses have demonstrated that distributions of mammals have been profoundly influenced by the extent of Pleistocene islands and by climatic variation along elevational gradients in the many mountains of the Philippines. Each Pleistocene island is a unique center of biodiversity, and many high mountains (or mountain ranges) are unique subcenters. Patterns of genetic variation within species match very well with these Pleistocene islands, suggesting that speciation and diversification within the Philippines is intimately tied to this geological history. Further studies are needed to integrate phylogenetic information with biogeographic and ecological data.

Ecological studies have demonstrated that species richness of some groups (e.g., bats) is highest in the lowlands, and that species richness of other groups (e.g., rodents) is highest at high elevations, often in lower mossy forest. Reproductive biology of fruit bats is well known from several studies, demonstrating that females of some small Philippine species are unique in being pregnant for 95% of their lives, but have low total

reproductive output. The reproductive biology of most Philippine mammals remains poorly known or unknown. Population ecology and community ecology are well-known at a few sites, but generally poorly known at this time. We do know that many natural communities are very species-rich and that densities are often very high, and that native and non-native species often have very different patterns of habitat use, feeding ecology, movement, and longevity.

Information on conservation status of mammals has improved greatly, with at least some information on distribution and abundance available for most species, and this allows us to estimate their decline in population due to destruction of habitat, and the relative vulnerability of most species. Recent studies of seed dispersal by fruit bats demonstrate their key role in naturally regenerating rain forest. Loss of about 94% of old-growth forest habitat has left many species highly vulnerable. The increase in number of protected areas (due in part to discovery of new species and biogeographic analysis) has improved the prospects for conservation, but more are needed. Current knowledge is sufficient to guide some crucial conservation efforts, but much essential information is not currently available.

Introduction

It is now generally recognized by both the scientific and the conservation communities that the Philippine Islands support one of the most species-rich, highly endemic, and highly endangered mammal faunas in the world (Groombridge, 1992; Mittermeier et al., 1997, 1999; Myers, 2000). The fact that this is recognized is due largely to research efforts that have taken place in the country during the last 20 years, and especially to the work done in the last decade. While there remain enormous gaps in our knowledge, enough is known to indicate that the Philippine mammal fauna has gone from one of the least-well known in the world to one of the better-known faunas in Asia, in terms of systematics, biogeography, ecology, and conservation status and priorities. The purpose of this paper is to identify the primary topics of research during the period of 1990 - 2000, and to identify the topics and issues that should be among the high priorities during the coming decade.

There are many formats that could be used for such a summary. In this paper, I will present information organized by research topic, rather than by taxon or by geographic region, simply because it reflects my own perspective. Within the four topical areas, I will primarily follow a taxonomic and/or geographic organization. In general, I refer only to published studies, because all others are effectively unavailable. While this review focuses on research published in the period of 1990 to 2000, I include a few crucial references from the late 1980s and a few publications currently in press.

Systematics

The most basic level of understanding for any fauna is the one that involves the ability to recognize species. Discussion of any other issue is made vastly more difficult when we do not know how to recognize or what name to use for an animal, and our ability to recognize the evolutionary relationships of species is key to many other topics of research; both of these topics can be approached through a variety of means, including morphological studies, karyological studies, and genetics.

Several groups of mammals have been the subjects of recent taxonomic studies, including shrews (Heaney and Ruedi, 1994), primates (Fooden, 1991a, 1991b; Timm and Birney, 1992), bats (Ruedas et al., 1994), murid rodents (Musser and Heaney, 1992; Musser et al., 1998; Rickart and Heaney 1991; Rickart et al., 1998; Ruedas, 1995), cats (Groves, 1997b), wild pigs (Groves, 1997a), and deer (Grubb, 1993). A summary of the Philippine mammal fauna (Heaney, 1998) listed 201 species, including 22 marine mammals, 172 native terrestrial mammals, and 7 introduced, non-native species; this included 16 species (eleven not yet formally described) discovered since the previous checklist published in 1988 (Heaney et al., 1988). Much of the fundamental work of

describing new species and rigorously defining genera remains to be done, with perhaps the greatest challenges among the murid rodents and insectivorous bats. Identification of bats has been eased by a key to species (Ingle and Heaney, 1992), and two brief field keys to the bats and the non-flying mammals of Mindanao (Ingle et al., 1999; Heaney et al., 1999), but for all other groups and areas, no keys are available.

Our ability to assess the relationships among species, and to verify their distinctiveness, has been enhanced by recent karyological studies of bats (Rickart et al., 1988, 1999) and murid rodents (Rickart and Musser, 1993). These studies have helped to identify aspects of the process of speciation, but only a small number of species in the Philippines have been karyotyped thus far, and much remains to be done. Studies of genetics (based on protein allozyme) are still fewer, limited to some data on shrews (Heaney and Ruedi, 1994) and on two species of fruit bats (Peterson and Heaney, 1993), with no published studies yet taking advantage of the newer DNA sequencing technologies.

Phylogenies have been presented only for shrews (Heaney and Ruedi, 1994), fruit bats and murids (Heaney and Rickart, 1990), and these were limited in scope and robustness. This limits our ability to interpret many issues (e.g., biogeographic patterns, evolution of life history traits and other ecological patterns), and represents a substantial current shortcoming to our knowledge.

Faunistics and Biogeography

Knowledge of the fauna requires that we understand the distributions and habitat relationships of every species, and that we recognize the general patterns that are formed by the sum of distribution patterns of individual species - the topics that are involved in biogeography.

Intensive inventories of faunas on specific islands or mountains include those of Catanduanes Island (Heaney et al., 1991), Leyte, Biliran, and Maripipi Islands (Rickart et al., 1993), Sibuyan Island (Goodman and Ingle, 1993), Camiguin Island (Heaney and Tabaranza, 1997), Siquijor Island (Lepiten, 1997), the Sierra Madre of northeast Luzon (Mallari and Jensen, 1993; Danielsen et al., 1994), and Mt. Isarog in southern Luzon (Rickart et al., 1991; Heaney et al., 1999), Mt. Kitanglad (Heaney, 2001), and with brief studies on Mindoro (Gonzalez and Dans, 1999; Ocampo et al., 1999). Field studies were conducted in many other areas during the decade, but the results have not been published. Because many of these inventories have resulted in the discovery of previously unknown species of mammals, they demonstrate that we still have much to learn about even the most basic aspects of mammalian biodiversity in the country. Intensive inventories such as these are needed in every part of the country, since most provinces and islands have had very few species recorded (Heaney et al., 1998, in press).

Analyses of biogeographic patterns among fruit bats (Heaney, 1991b) have shown that these animals likely entered the Philippines from both the Southeast Asian mainland and New Guinea/Australia, that most of the Pleistocene islands in the Philippines have unique species, and that species richness is related to island area. Much evidence supports the hypothesis that there are strong interactions between elevational patterns and distributional patterns among fruit bats and murid rodents, such that species that live in the lowlands tend to be widespread on many Pleistocene islands (defined as those connected to each other during periods of low sea level; Heaney, 1991a) within the archipelago, whereas those in the highlands usually are restricted to a single

Pleistocene island and often show evidence of speciation within a given Pleistocene island (Heaney and Rickart, 1990). Each of these Pleistocene islands is a separate center of endemism, with 40-90% of the non-flying mammals unique to the Pleistocene island (Heaney, 1993; Heaney and Regalado, 1998). Patterns of genetic variation within two species of fruit bats match the general biogeographic patterns very closely (Peterson and Heaney, 1993). Independent patterns of variation in karyotypes within several groups of bats strongly reflect biogeographic patterns (Rickart et al., 1999). A general model of island biogeography suggests that species richness on any given island is influenced by direct colonization from other islands (and occasionally the continent), by extinction, and by phylogenetic diversification within the archipelago, with local phylogenesis potentially accounting for up to about 75% of the biodiversity of a given group (Heaney, 2000). During the coming years, biogeographic analysis needs to focus on poorly-known parts of the country (such as the Batanes, Babuyan, and Sulu groups and the mountains of Mindoro, Palawan, northern Luzon, Panay, and southern and western Mindanao), on integrative studies of phylogeny and distribution (= "phylogeography"), on measuring rates and mechanisms of natural colonization, speciation, and extinction, and on integrating biogeographic data with ecological data on such topics as elevational distribution, life history traits, habitat use, foraging ecology, and community structure. These studies should include species of large and small body size, flying and non-flying species, and high and low elevation habitats in order to detect and document the major patterns.

Ecology

Much of what has been learned about the ecology of Philippine mammals has taken place in the context of studies of how they are distributed along elevational gradients. It is now recognized that such gradients play a key role in determining the distribution and abundance of all species (Rickart, 1993), perhaps associated with the vegetation changes that accompany the extreme variation in rainfall (usually ca. 2 m in the lowlands, and up to 12 m per year in mossy forest; Balete and Heaney, 1997). The initial studies of fruit bats, shrews, and rodents on Negros and Leyte islands (Heideman et al., 1987; Heaney et al., 1989) have been followed by those on Mt. Isarog, southern Luzon (Rickart et al., 1991; Balete and Heaney, 1997; Heaney et al., 1999), on Camiguin Island (Heaney and Tabaranza, 1997), and on Mt. Kitanglad (Heaney, 2001). These studies have demonstrated that species richness of fruit bats, and probably insectivorous bats, is highest in the lowland rain forest and declines steadily with increasing elevation. They have also demonstrated that small mammal diversity (shrews and rodents) is low in the lowlands, increases to about 1800 m elevation, and (when the mountain is higher) decreases at progressively higher elevation. This latter pattern of a mid-elevation peak in diversity is increasingly being recognized as a common pattern in many parts of the world (Heaney, 2001). Limited data suggest that mammal faunas on small, depauperate islands may not show these same patterns; further, it is unclear how differences in annual precipitation may affect the specific pattern; and there are many, poorly-evaluated hypotheses as to why these two patterns exist (Heaney, 2001). Much research will be needed to resolve these questions.

There are certain habitats or resources that are critically important to the ecology of some species; for example, it is likely that caves are essential for the survival of many of the species of both fruit and insect-eating bats. However, no

studies of either caves or other equivalent crucial resources have yet been published.

The reproductive biology of Philippine mammals is generally poorly known, with one dramatic exception - the small fruit bats. Through a series of papers by Heideman and his colleagues (Heideman, 1989, Heideman et al., 1993, Heideman and Powell, 1998), we now know that the small endemic genera (*Haplonycteris* and *Otopteropus*) are unique among all mammals in their reproductive patterns. Females become pregnant at about 9 months of age, and these young adults and all adult females in a population each give birth to a single young during a single 10-day period, mate and become pregnant about two weeks after birth, and are pregnant for the rest of the year, including a period of about eight months of arrested development of the implanted embryo. This means that they are pregnant for 95% of their lives. *Ptenochirus* has a similar pattern, but gives birth twice each year (Heideman and Powell, 1998). Reproduction by other species in the country is known only by the number of embryos and time of year when they give birth, or by no data at all. There is great opportunity and need for many more studies of reproductive biology.

Population ecology of fruit bats has been studied in detail by Heideman and Heaney (1989), Ingle (1992, 1993) and Utzurrum (1995), who found them to be characterized by a low rate of reproduction, long lives, and high density. In general, these bats have either small home range size (the endemic genera) or very large home ranges (the widespread Southeast Asian genera). The widespread Southeast Asian fruit bats (and many insectivores) tend to live in disturbed habitats, whereas the endemic species of fruit bats (and many endemic insectivorous bats) live in old-growth or high-quality secondary forest (references above and Heaney et al, 1991, 1999; Rickart et al., 1993). An unpublished PhD dissertation on the foraging ecology of insectivorous bats (Sedlock, 2001) provides a first glimpse of how this diverse part of the mammal fauna uses habitats and food resources. One initially startling discovery is that many murid rodents feed heavily on earthworms, and that density of these specialist vermivore rodents is highly correlated with that of their earthworm prey (Rickart et al., 1991). The single study of forest rodent population ecology (Balete and Heaney, 1997) demonstrated high density of both omnivorous and vermivorous/insectivorous species in mossy forest, and home range size for most species of one-fourth to one-half hectare, which is moderately large. There is great need for many more studies of population ecology, undertaken on single species and complete communities, at all elevations, and of all groups of species, if we are to understand how these animals have evolved in response to their island environment, and, on the basis of that information, how to effectively conserve them.

Conservation Research

While conservation of Philippine mammals has received attention for many decades (reviewed by Rabor 1966; Gonzales and Alcala, 1969; Tabaranza, 1979), some fundamental changes have taken place recently, especially in the last decade. Previously, most attention regarding mammals was given to a few large species (e.g., tamaraw and Calamianes spotted deer) and unusual species (e.g., tarsier and flying lemur), and to a semi-captive population of non-native African large mammals on Calauit Island. For these few species, nearly all effort went to captive breeding; the bulk of Philippine endemic mammals were not considered. Within the last decade, the emphasis has shifted strongly to a much broader concern for the entire mammal fauna, regardless of body size or popular appeal. This has been associated with the growing body of information about the natural history of the mammal fauna as a whole that was described above, but has also been associated with a recognition that habitat conservation needs to play a much greater role in preservation of the Philippine biota. Awareness that Philippine old-growth rain forest has declined from about 70% in 1900 to about 6% currently has reached the public in part due to the educational efforts of members of the Wildlife Conservation Society of the Philippines (WCSP). Further, the recognition that at least 111 endemic mammals species are present and depend on good-quality rain forest is due largely to the efforts of members of the Wildlife Conservation Society of the Philippines. Some of the key issues and new perspectives concerning conservation of Philippine mammals that have been documented during the past decade, especially those resulting from new research, are the following.

Patterns of diversity and endemism. The Philippine system of parks and protected areas initially was not based on biological criteria, but rather on political criteria. Beginning in about 1988, biologists began to advise governmental, non-governmental, and international agencies (including the Department of Environment and Natural Resources, World Bank, European Union, IUCN, World Wildlife Fund, and Conservation International) on patterns of biotic diversity in the archipelago. In particular, the seemingly complex patterns of endemism within the archipelago were clarified by biogeographic studies that showed the extent of islands during the late Pleistocene period of low sea level; each late Pleistocene island that has been inventoried is a unique center of endemism, with 50 - 80% of the terrestrial mammals being unique (Hauge et al., 1986; Heaney, 1986, 1991b; Heaney and Regalado, 1998). This approach to understanding biodiversity patterns in the archipelago was used recently as the primary baseline for structuring all data and analysis in the National Conservation Priority-Setting Workshop organized by the Department of Environment and Natural Resources and Conservation International in 2000-2001 (Ong et al., in press). This research has also allowed documentation of gaps in the current protected areas system and assessment of priorities for development of protected areas (e.g., Heaney and Mallari, in press; Heaney et al., in press).

Discovery of new species and the need for new national parks. As biogeographic and systematic research has progressed, it has become apparent that certain areas were likely to be centers of endemism, but were nearly or entirely unknown in 1990. For example, the previously unknown mammals of Sibuyan Island, an isolated oceanic island surrounded by deep water, were inventoried in 1989 and 1992. Five new species of mammals were discovered, all endemic to the island (Goodman and Ingle, 1993; Heaney et al., 1997, 1998), resulting in much of the island being declared a national park, and the park being included in the list of eight national parks funded by the European Union through the National Integrated Protected Areas Program. Similarly, Camiguin Island had been surveyed briefly (reported in Heaney, 1984), and no endemic mammals were known, but later analyses indicated that endemic species should be present. Surveys in 1994 and 1995 discovered two distinctive species of rodents (Heaney and Tabaranza, 1997), and resulted in declaration of the mountainous core as a national protected area. Discoveries of new species on Mt. Isarog (southern Luzon) and on Mt. Kitanglad (northern Mindanao) had similar impact on areas that had been given little attention. The discovery of a new species of cloud rat on Panay Island (Gonzalez and Kennedy, 1996) has heightened focus on that island and has led to proposals for designation of a "Panay Mountains National Park", and attention is now being drawn to Balbalan-Balbalasang National Park, an area of unusually high biodiversity in the northern Central Cordillera of Luzon (Heaney et al., 2000). Rediscovery of "extinct" birds and bats on Cebu Island is having a markedly positive effect (Oliver and Pedregosa, unpubl.).

Documentation of the conservation status of mammals. As noted above, previous listing of the conservation status of mammals in the Philippines included only a few large and taxonomically distinctive species. Field studies during the last decade have allowed us to make reasoned judgements of the status of most species, based on actual distributions, habitat requirements, status of the habitat, relative abundance, and assessment of the impact of hunting; for all but a very few species, these had been virtually or entirely unknown. These assessments (e.g., Cox, 1987; Garcia and Deocampo, 1997; Heaney and Heideman, 1987; Heaney and Utzurrum, 1992; Oliver, 1992, 1994, 1999; Oliver et al., 1992, 1993a, 1993b); Heaney et al., 1997, 1998; Utzurrum, 1992; Wildlife Conservation Society of the Philippines, 1997) form the basis for the IUCN Red Data Books (Baillie and Groombridge, 1996) and other similar listings. As a result, some species, including the wood-shrew (*Podogymnura truei*) and tarsier (*Tarsius syrichta*), have been delisted (both are abundant in widespread suitable habitat), but 52 others have been added to the official lists.

Demonstration that mature forest is essential for most species of Philippine endemic mammals. Recent field work has nearly always compared the mammals present in forest of varying degrees of disturbance and agricultural areas, and has produced clear evidence that most of the endemic species, especially those that are threatened, require forested areas with only limited disturbance due to logging (e.g., Heaney et al., 1989, 1991, 1999; Heideman and Heaney, 1989; Ingle, 1992, 1993; Lepiten, 1997; Mallari and Jensen, 1993; Rickart et al, 1991, 1993). These data are often utilized in discussions about the desirability of continued commercial logging in the country. Reforestation with exotic species such as *Gmelina* and *Eucalyptus* is unlikely to promote biodiversity conservation because these species produce tree plantations that are virtually biologically sterile; "re-rain-forestation" in nature is promoted by seed dispersal from remnant forest by birds and bats (Utzurrum, 1995; Ingle, unpubl.) While the debate about logging and reforestation is likely to continue for some years, there is no doubt that biological data, including data about the magnificent endemic mammalian fauna, will play a meaningful role in the future, as the public and government officials recognize that all aspects of the ecosystem, both natural and human-dominated, are interconnected, and that stability of human economic, social, and political systems require stable biological systems.

Some thoughts on the future of research on Philippine mammals

Realistically, it is unlikely that we can anticipate many of the needs for research of the coming decade, much less the conceptual/ theoretical issues that will develop unexpectedly. However, it may still be worthwhile to emphasize some of the current large gaps in our knowledge, and some of the conceptual issues that seem likely to be especially productive.

A recent compilation has demonstrated that most of the provinces on Luzon and Mindanao, and many of the medium and small islands around the country, have not yet been the subject of even the most basic and superficial biological survey (Heaney et al., in press). Obtaining information on the distribution and status of species is the most fundamental issue for both conceptual understanding and for well-planned and successful conservation. In the course of such research, it is virtually certain that new species will be discovered, and these should be described and their basic biology documented. The voucher specimens that are produced will also allow other taxonomic studies that will certainly enlighten us about Philippine biodiversity.

One exciting new area for investigation is the historical development of patterns of biological diversity - the investigation of how the biological diversity of the archipelago was generated, in the context of our greatly increased understanding of the geological history of the islands. Molecular techniques (especially DNA sequencing) hold great promise for helping us to define the evolutionary relationships of species, to determine their place of origin outside of the Philippines, and to document their means of diversification within the archipelago.

Ecological studies need to focus on at least two major issues: first, how the communities of organisms manage to co-exist at a single locality (the ecology of communities); and second, how species respond to various levels of habitat disturbance and destruction (population ecology). These data will be crucial for developing management plans that minimize the impact of humans on the natural biodiversity of the nation, as well as for understanding the natural functioning of this remarkable center of biodiversity. The ecology of special habitats, especially caves, is badly in need of attention.

Conservation research studies need to continue to work hand-in-hand with basic ecological and systematic biodiversity research; I hope that, if nothing else, this review has demonstrated that there can be no real progress on conservation without being a part of on-going basic biodiversity research programs. Moreover, all of the research programs and issues discussed above depend heavily not only on high-quality field work, but also on consistent and timely scholarship - the frequent and careful publication of the results of research and conservation programs, so that the information becomes a matter of public record. Without publication, all of our work could ultimately be little more than an expensive and unproductive hobby.

Finally, during the last decade, we have learned that successful research and conservation depends on the full recognition by regulatory agencies—especially the Department of Environment and Natural Resources and the Protected Areas and Wildlife Bureau—that research on the biota of the Philippines, including mammals, is needed for the welfare of the nation and its natural patrimony, since conservation is fundamentally dependent on good and current data based on carefully conducted, thorough field research. The recent experience with the unintended will work to the benefit of the nation by promoting the most active, high-quality national research program possible on the amazing biodiversity of the nation.

Acknowledgments

I thank the Department of Environment and Natural Resources, especially the Protected Areas and Wildlife Bureau, for encouragement, assistance, and permits for field studies during the last decade. Funding for this research has been provided by the National Science Foundation (BSR-8514223), the Smithsonian Institution Office of Fellowships and Grants, the Barbara Brown, Marshal Field, and Ellen Thorne Smith Funds of The Field Museum, and the John D. and Catherine T. MacArthur Foundation (90-09272A). I thank Nina R. Ingle and Eric A. Rickart for their comments on an earlier draft.

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NEGROS RAINFOREST CONSERVATION PROJECT: PAST, PRESENT & FUTURE

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ABSTRACT

The Negros Rainforest Conservation Project (NRCP) is a joint program of collaborative research, education, and training between the Negros Forests and Ecological Foundation, Inc. (NFEFI) and Coral Cay Conservation (CCC). The project is situated in the North Negros Forest Reserve (NNFR), Negros Occidental, the Philippines. The primary scientific objectives of the project are to collect biodiversity inventory data and to conduct complementary ecological research on species involved in the NFEFI species recovery program to aid in-situ conservation initiatives. The project utilizes trained volunteers to collect baseline biodiversity data in order to increase the understanding of the ecological dynamics and community composition of the different forest types within a restricted area of the NNFR.

This paper presents an overview of the work of the NRCP and reports on the preliminary inventory and census data compiled by the project. These results do not only begin to confirm that the NNFR is an important biodiversity hotspot with a huge diversity of endemic and endangered species, but also underline the data gathering capacity of the NRCP. These initial empirical results and integrated approach of the NRCP are utilized to outline how this information could quantitatively underpin the conservation objectives of NFEFI, and contribute to the development of an integrated, community-driven conservation and sustainable management of the biodiversity of the NNFR.

The Forests of Negros

The Philippines has one of the highest rates of tropical forest loss, declining from 70% to 18% cover in the last 100 years (ESSC 1999, DENR/UNEP 1997). On Negros Island under 5% of the original forest cover remains intact (Heaney

& Regalado 1998). Such whole scale loss means that approximately 60% of endemic Philippine flora is now extinct (Roque *et al*, 2000). As a result, the moist forests of the Philippines are now classified as the eighth most vulnerable forest ecoregion in the world (WWF 2001). Such rapid loss of tropical forest habitat has serious implications for the terrestrial biodiversity of the Philippines. Over 57% of species in the major faunal groups occur nowhere else in the world (Oliver & Heaney 1996) and many of these have restricted ranges within the Philippines. The remaining forested habitat is of critical importance to all groups, but particularly the birds, with over 80% of threatened Philippine bird species dependent on the remaining tropical moist forests (Collar *et al*, 1999). With much of the remaining tropical forest cover restricted to small montane areas, it is now apparent that even low levels of deforestation can seriously threaten montane faunas of restricted distribution (Brooks *et al*, 1999). The area covered by the Negros Rainforest Conservation Project is the largest remaining area of wet evergreen rain forest on Negros (Hamann *et al*, 1999), and the second largest in the West Visayan Faunal region that including Negros, Panay, Guimaras, and Masbate. It also falls into the IUCN category of the highest conservation priority (Dinerstein 1995).

The NNFR represents one of these montane areas. It is considered to be of importance to the survival of many critically endangered endemic and restricted range species found only within the Negros-Panay Faunal region, the most threatened of the Philippines' five faunal regions (Heaney & Regalado 1998). These endemic species include threatened birds such as the critically endangered Walden's Hornbill (*Aceros waldeni*) and the endangered Visayan Tarictic Hornbill (*Penelopides panini*). The mammal fauna includes the endangered Philippine spotted deer (*Cervus alfredi*) and the critically endangered Philippine warty pig (*Sus cebifrons*)

(WCSP 1997). Both species have been extirpated from 95% of their former range (Cox 1987), having once been common throughout the West Visayas. *C. alfredi* is considered to be extinct on the islands of Cebu, Guimaras, and Masbate (Oliver *et al*, 1992). As their status and distribution on Negros is uncertain, census information is urgently needed for effective conservation and management.

Current Knowledge and Needs

In addition to harboring immense biological diversity, these montane forests are also a source of vital ecosystem goods and services. For example, they are a potential source of many non-timber forest products (NTFPs) such as rattan and bamboo (DENR/UNEP 1997). They protect vital watersheds (Penafiel 1994), providing a clean and controlled supply of water to the provincial capital of Bacolod and other areas. These benefits are beginning to be recognized at international, national, and local scales (Heaney 1993; Heaney & Regalado 1998; WWF 2001).

The best strategy for effective conservation, whether by inclusion in the National Integrated Protected Area System (NIPAS), or via stakeholder management, or a combination, is still unclear. But what is recognized is that the adoption of any or all of these approaches will require spatially referenced ecological data in order to guide effective conservation management of diverse forest habitats (Alder & Synnott 1992; DENR/UNEP 1997). However, one of the greatest problems has been the paucity of accurate and current information on the wildlife and forests of the Philippines (Heaney & Regalado 1998) that can provide a baseline inventory to underpin future conservation strategies.

It can be argued that such information exists in one form or another since the fauna and flora of Negros Island are well studied in comparison to other areas of the Philippines (Angel Alcala pers. comm). Unfortunately this is only for particular groups such as mammals (Heaney *et al*, 1989; Heideman *et al*, 1987), herpetiles (Brown & Alcala 1986), and avians (Brooks *et al*, 1992), with such work being completed with differing levels of inclusiveness in a limited range of habitat types. On the other hand, the montane areas of the Philippines, which now represent the majority of the remaining forest fragments, have hardly been explored (Ashton 1993). These include the montane forest areas of Negros. To date, only a limited number of short studies on an equally limited number of taxonomic groups have been published (Hamann *et al*, 1999; Hamann & Curio 1999; Heindl & Curio 1999; Heideman *et al*, 1987; Brooks *et al*, 1992). This has resulted in a patchy array of detailed studies with many gaps in current knowledge regarding forest community compositions and wildlife diversity and distribution. A more comprehensive survey of the differing forest types and the mosaic of natural and anthropogenically affected habitats that are known to exist in the NNFR should be completed before any conservation management or restoration strategies can be effectively planned.

This paper broadly reviews the ecological survey work undertaken by the NRCP; however, it does not attempt to offer a complete and detailed analysis of the inventory data. Such data will be presented in subsequent technical publications.

The Negros Rainforest Conservation Project

In response to the need for ecological information

crucial in making informed decisions regarding the sustainable management of the NNFR, the Negros Forests and Ecological Foundation Incorporated (NFEFI) has asked Coral Cay Conservation (CCC) to assist in the provision of resources in undertaking baseline biodiversity surveys. This cooperation has resulted in the establishment of the Negros Rainforest Conservation Project (NRCP) in 1999. Oliver and Heaney (1996) have recognized the need for locally based conservation initiatives and stressed the importance of not becoming dependent on international assistance. Cognizant of this sentiment, NRCP has realized this goal through its partnership program with CCC. In this arrangement, CCC supports NFEFI's use of trained volunteers in undertaking the ecological inventory and census work.

Primarily, the ecological survey work will gather baseline quantitative data on the biodiversity of the fauna and flora of the North Negros Forest Reserve in order to create resource maps and an environmental database for the region. A major part of this survey work is a complementary field-based research into the habitat requirements and ecology of the endemic species currently included in the NFEFI captive breeding program whose objective is to produce guidelines for effective forest management to aid *in-situ* conservation of specific species. In addition, this survey aims to generate suitable education materials to be used in inculcating environmental awareness among local communities and in designing training programs in biodiversity assessment & management for host country's counterparts. Finally, data from this survey will be used to formulate an integrated, community-driven management plan for the conservation, restoration, and sustainable use of biodiversity in the region.

At the international level, such work will contribute to global efforts such as the Tropical Montane Cloud Forest initiative (Aldrich 2000). At the national level, it will contribute to the National Biodiversity Strategy and Action Plan, which includes inventories of flora and fauna as well as mapping of biodiversity rich areas not covered by NIPAS or declared protected areas. At the local level, the project will provide NFEFI and Local Government Units (LGUs) vital ecological data for conservation management in the NNFR. The information will also be available for the development of education initiatives, and training in biodiversity assessment and management.

Data Collection Methods

Volunteers - The NRCP undertakes rapid biodiversity assessments of major faunal groups (focussing on birds, mammals, reptiles, amphibians, and insects) in conjunction with long-term vegetation monitoring. In undertaking this project, NRCP uses volunteers (local and international) who are trained by experienced graduate and postgraduate ecologists. The training includes an intensive and comprehensive one-week course in field monitoring techniques. Volunteers are expected to achieve a minimum basic standard of competence before undertaking any fieldwork. While the use of volunteers may be questioned with regard to expertise in data collection, the fact that conservation biologists have long used "non-professional" volunteers to collect much of the information needed to make informed decisions concerning resources they are trying to protect is widely acknowledged (Bildstein 1998). There is also a growing body of literature supporting the use of trained volunteers in baseline ecological monitoring work where resources are limited (Fore *et al*, 2001; Rosenburg *et al*, 1998; Mumby *et al*, 1995; Darwall *et al*, 1996; McLaren & Cadman 1999).

In addition to training and supervision, the NRCP also uses survey techniques that require minimal expertise yet permit the collection of accurate ecological data. For example, bird surveys are completed both by mist netting (Bibby *et al*, 1998) which allows accurate identification of each specimen and by the use of observation techniques such as Mackinnon lists (Mackinnon & Philips 1993). The Mackinnon list method can be used to generate diversity and relative abundance data, and is useful for more inexperienced observers (e.g. volunteers) as time can be spent identifying individuals without distorting the results (Sutherland 2000). However, tropical forest surveys are often synonymous with a high demand on research resources and technical expertise for surveys on lesser-known taxa, particularly some insect groups (Willott *et al*, 2000). Such issues can be partially ameliorated by using, for example, readily sampled groups such as butterflies, because they are relatively easy to record and identify (Kremen 1994), and can be used as an effective "umbrella group" for biodiversity conservation (New 1997).

Tree Species Inventory - Vegetation survey work has been undertaken using six permanent sample plots which have been established within three forest types of the NNFR (in close proximity to the village of Campuestohan 10° 39'N, 123° 08'E, on the southwest perimeter of the NNFR) to enable comparisons of community composition of the different forest types and species distributions within them. The plots have been permanently established in parallel pairs, in each of three different forested areas: (1) *Lightly disturbed old-growth forest* - selectively legally logged for dipterocarps 35 years ago; (2) *Heavily disturbed old-growth forest* - forest, legally logged for dipterocarps, and illegally logged for other species with commercial value 11 years ago; (3) *Secondary forest* - on a clear-cut site, where regrowth began 11 years ago.

Based on international standard methodology for tree inventory work, one-hectare plots (500m x 20m) subdivided into 25 quadrats of (20m x 20m) were used (Hamann *et al*, 1999, Alder & Synnott, 1992; Dallmeier 1992; Madulid 1996; Pipoly & Madulid 1998). Subsequently, all specimens of ≥10cm dbh (diameter at breast height) were permanently tagged and identified with local names by local guides. Botanical samples were also collected and sent for species identification at the Philippine National Museum, Manila and Royal Botanic Gardens, Edinburgh.

Vertebrate Surveys - The vertebrate faunal surveys initially focussed on birds and mammals. The bird surveys were undertaken using Mackinnon lists (as discussed) and by point counts (Bibby *et al*, 1998; Stork & Davies 1996; Gibbons *et al*, 1996). These survey methods are ideal for rough terrain and dense vegetation where conditions make transect walking difficult (Bibby *et al*, 1992). The data produced are semi-quantitative and allow limited comparisons. Point counts allow easier identification of species which are often difficult to see because of the dense vegetation. For this reason, this method is best carried out by trained volunteers (Stork & Davies 1996).

With the guidance of NRCP staff, assessment of bird and bat diversity was conducted through observation work and by mist netting. Nets were established where capture efficiency was likely to be maximized (in clearings, along ridges or by water), following the approach of previous studies (Heaney *et al*, 1989). For mammal inventories the project used live traps following the trap line methodology of Heaney *et al* (1989) and Heideman *et al* (1987). In addition to the trap lines, the project used visual encounter surveys and species signs (e.g. tracks) according to the basic census techniques of Rabinowitz (1997).

Invertebrate Surveys - Regular butterfly surveys have been undertaken within the three forest types to investigate butterfly diversity, spatial distribution, and relative abundance. The project used the transect walk method with non-random point counts (Walpole & Sheldon 1999; Pollard, 1977), as used in previous studies of tropical forest butterflies (Hamer *et al*, 1997; Hill, 1999). As with the bird surveys, this survey method is ideal for rough terrain and dense vegetation. Baited traps (Ausden 1997) have also been used on each plot since this type of survey is particularly useful for surveying the guild of fruit-feeding butterflies. A type specimen of each species has been collected and identified to sub-species level using D'Abrera (1982; 1985; 1990), Tsukada (1981; 1982; 1985; 1991) and Baltazar (1991). These specimens are stored at the NFEFI for use in generating a photographic field guide that will aid future volunteer training as well as for educational purposes.

PRELIMINARY CENSUS AND INVENTORY RESULTS

Botanical Inventory - Nearly fifteen thousand individual trees (dbh≥10cm) have been permanently tagged within the six survey plots. One hundred and twenty morphological types of trees have been identified but this is likely to increase as scientific identifications are confirmed. Preliminary analysis revealed that the overall species richness and Simpson's diversity (Begon *et al*, 1990) are higher in the disturbed old-growth forest (95 species, diversity index = 21.57) and secondary forest (92 species, diversity index = 20.63) than in the old growth forest (72 species, diversity index = 12.54). The two old-growth areas also have a more even distribution of species in comparison to the secondary forest, and all forest areas demonstrated high diversity but low abundance of individual species.

As the evaluation of species composition showed clear differences between the different forest types, further patterns in community composition were assessed using PRIMER (Plymouth Routines in Multivariate Ecological Research) (Clarke & Warwick, 1994a). Community (species abundance) data were double-square root-transformed to reduce the influence of dominant and rare species. The Bray-Curtis similarity measure was then calculated between every permutation of sample pairs (Clarke & Warwick 1994b). The relationship between the forest types was displayed using a non-metric multidimensional scaling (NMDS) ordination (Figure 1) and a hierarchical agglomerate clustering technique (Figure 2) (Clarke & Green 1988).

The NMDS and Cluster demonstrated clear similarities between the pairs of sample plots located in the same forest type, indicating similar community composition. The relatively low stress value of the NMDS (<0.1) also demonstrated good separation of the three forest types, indicating that they differ substantially in their relative compositions. The Cluster also confirmed that the four old-growth forest plots are more similar to each other than to the secondary forest plots that are dominated by pioneer species (e.g. *Euphorbiaceae*). However, there is evidence that old-growth species, such as *Palaquium* species and *Agathis philippinensis* are re-growing at these sites.

The disturbed old-growth and old-growth forest plots were also found to be very different from each other in their species composition (Figure 1) with the latter being dominated by palm species which have been completely removed from the secondary forest.

Vertebrate Surveys - Over 200 hours of observation by 90 volunteers have resulted in the identification of 123 bird species from 33 avian families. This figure represents

approximately 20% of all species (572 in total) known to occur in the Philippines (Kennedy *et al*, 2000) and 1% of global bird species. Over 30% of all species identified within the NNFR are endemic to the Philippines, with sub-species endemic to the Negros-Panay faunal region. Nine of the species recorded in the NNFR are IUCN Red Listed (Table 1). Five of the Red Listed species identified, including the Visayan Flowerpecker (*Dicaeum haematostictum*), the Flame-templed Babbler (*Stachyris speciosa*), and the Visayan Tarictic Hornbill *(Penelopides panini)*, are restricted to the Negros-Panay Faunal region (Stattersfield *et al*, 1998).

The preliminary inventory of mammals (Table 2) already indicates that the NNFR is a key site for the endangered mammal fauna of the Philippines, yet this is far from being a definitive inventory. The Visayan Spotted Deer and Visayan Warty Pig, two of the most endangered animals in the world are known to be present in the NNFR. So far only deer tracks have been located, although there have been frequent sightings of pig activity, and of the pigs themselves, throughout the areas being studied.

With the use of mist-netting, the majority of the recordings consist of fruit bats, in particular, *Cynopterus brachyotis* and *Haplonycteris fischeri*. Another species, *Nyctimene rabori*, previously thought only to occur in Southern Negros, being restricted to undisturbed, primary, lowland forest, has been caught in the secondary forest near the NRCP research center. Rare or uncommon in all known sites, and facing extinction on Negros, this bat species is classified as IUCN critically endangered (Heaney, 1998).

The observation and live trapping work have also located Long-tailed macaques (*Macaca fascicularis*) close to the research center and within the survey sites between December and July. Two sites have been identified as being particularly important: Baldusa Falls and Hiyang-Hiyang. Common palm civets (*Paradoxurus hermaphroditus*), Malay civets (*Viverra tangalunga*) and an array of small mammals (Table 2) are also known to be active in all areas surveyed. However, the small mammal fauna is dominated by non-native species such as the Asian house shrew (*Suncus murinus*), the Oriental house rat (*Rattus tanezumi*), and the Polynesian rat (*Rattus exulans*).

Invertebrate Surveys - The NRCP has collected and identified 38 butterfly species and sub-species from 7 families (Figure 3) and nearly 80% of the species identified are endemic to the Philippines. It is also apparent that a number of the species have restricted geographic distributions within the Philippines (Figure 4). There were also differences in butterfly diversity, richness, and abundance between the three forest types, with the secondary forest displaying higher species richness but lower abundance and reduced species diversity (Simpson's diversity (Begon *et al*, 1990)) than the old-growth sites.

DISCUSSION

The data presented here are still preliminary but they serve to illustrate the value of the NRCP data collection process and capacity. To date the NRCP has located 123 bird species within the NNFR, which is greater than previous studies (Brooks *et al*, 1992; Hamann & Curio 1999), and will contribute to the first detailed avian inventory of this area. The surveys also reinforce the ecological importance of the NNFR for both endemic and IUCN Red Listed species, confirming the findings of earlier works (Brooks *et al*, 1992; Hamann & Curio 1999; Heindl & Curio 1999; Heideman *et al*, 1987). They also present the first records for several species from different faunal groups, such as the Philippine Hawk-eagle (*Spizaetus philippensis*) and the Philippine tube-nosed fruit bat *(Nyctimene rabori)*.

Clearly, the inventory total is a function of surveyor effort, but it serves to illustrate the value of long-term studies when attempting to generate species inventories.

Detailed inventory and census work represent the first step in the conservation management process since ecologically sound forest management, whether for conservation alone or in conjunction with sustainable resource use, will only be successful if the dynamic behavior of the systems can be adequately characterized and predicted (Alder & Synnott 1992). Permanent sample plot studies used in combination with baseline faunal surveys for all major habitat types have provided us with an opportunity to assess ecological patterns and changes along spatial and temporal dimensions. Therefore, they have a central role in many aspects of tropical forest research, conservation, and management. For example, the empirical outputs of the completed permanent sample plot inventories will not only provide a valuable baseline for vegetation community structure and how this relates to faunal diversities and distributions, but will also aid reforestation efforts.

Comparison of species frequencies on different plots (within different forest types) might help conservationists decide which species are useful for reforestation projects. For example, a species that occurs in scattered patches in an old growth plot, but forms high frequency populations on the logged over site (e.g. *Euphorbiaceae sp.*), is likely to be a pioneer species. Because such species is generally tolerant of drought and intense sun, it may be used to establish new plantations by open field planting. Results of this sort are only possible to achieve when the scientific inventory will have been completed, and only then will it become possible to plan restoration initiatives for areas such as the NFEFI and the Upper Imbang-Caliban watershed.

Acquisition of detailed ecological inventory data also forms part of the resource profiling process that is a necessary step for designating protected areas (Carlo Custodio [PAWB] pers com.). However, detailed conservation planning requires rapid ecological assessments of many other locations within the NNFR in order to adequately characterize the spatial distribution and abundance of species and habitats in relation to environmental gradients. This requires time and the staff's ability to work at appropriate spatial scales.

The project's unique participatory model utilizing trained volunteers represents an opportunity to increase both the spatial and temporal scales in undertaking such inventory work. With this model, it will be possible not only to evaluate the composition of the fauna and flora in differing forest types, but also to monitor change over time, thus accomplishing major research goals with minimal resources. Too often, conservation research is restricted by available resources such as funding, logistical constraints of working in remote forest fragments, and availability of personnel that can spend adequate time in the field in order to achieve research objectives. However, the participatory model of operation of the NRCP offers one possible solution to sustaining such field based research initiatives.

However, it is important to acknowledge the technical constraints presented by the use of volunteer (novice) labor when collecting scientific data. The NRCP has always used internationally recognized and published survey methods (for major faunal and floral groups), but in order to make these methods workable, reliable and provide data in a format that is usable, they have to be adapted for volunteers and local community members. Thus, a situation- specific development of

methods is necessary if accurate and scientifically robust information is to be gained and recognized by peers. Although the perceptive accuracy of data collection may be enhanced through the use of appropriate methods and training, there is still a need to validate any data collection process (MacLaren & Cadman 1999). To this end, the NRCP is currently undertaking a study to validate the data collected by the volunteers who used observation techniques.

While the research lessons continue to be learned, one outcome of the project is clear. The NRCP would not have been sustained for this long without research collaboration and continued local support. Local NGO support, community involvement, and the willingness of local and international researchers to contribute to the project provide the foundation on which the day-to-day research is completed. While the social, political, and economic reasoning for such involvement is well rehearsed, the scientific value of the participatory exchange of knowledge cannot be overstressed in an area that is biologically poorly known and documented, at least in a scientific sense. The inventory and census data are only an initial step while the task of conserving and restoring the forests of the NNFR and Negros is vast. There is a need to look at alternative mechanisms by which to achieve conservation goals and it is now acknowledged that volunteers will play increasingly important roles in wildlife conservation wherever their efforts can be coupled with those of professional practitioners in the field (Bildstein 1998). The NRCP is by no means a panacea but through partnership and collaboration, and the continued involvement of volunteers and local communities, it offers a mechanism through which to make small steps in the right direction and assist in sustaining the resources of the NNFR.

Acknowledgments

The NRCP is indebted to the Department of the Environment and Natural Resources (DENR) for continued support and issuance of the Wildlife Gratuitous Permit. We also express thanks to the staff of NFEFI for their continued support. We would also like to thank the many and varied research collaborators who have assisted and supported various aspects of the project, including Dr. Madulid (Philippines National Museum), Peter Wilkie (Royal Botanic Gardens, UK), Thomas Brooks (Conservation International), Apolinario Carino (CENTROP), Marisol Pedregosa (Cebu Biodiversity Conservation Project), and Charles Hesse (Ornithologist, UK). Additionally, we would like to thank the anonymous referee for comments on an earlier version of this manuscript. Finally, we would like to thank the people of Campuestohan and the field staff and volunteers of CCC/NFEFI for their support and efforts with the survey work.

Table1. Threatened bird species located within the NNFR

SPECIES	STATUS	GEOGRAPHICAL DISTRIBUTION	ALTITUDINAL RANGE	FOREST TYPE	ENDEMIC
White-winged Cuckoo-shrike (*Coracina ostenta*)*	vulnerable	Negros-Panay	<2000	2	yes
Visayan Flowerpecker (*Dicaeum haematostictum*)*	endangeed	Negros-Panay	<1000	2	yes
Flame-templed Babbler (*Stachyris speciosa*)*	endangered	Negros-Panay	<1000	1	yes
Negros Bleeding-heart (*Gallicolumba keayi*)*	critical	Negros-Panay	<1200	2	yes
Visayan Tarictic Hornbill (*Penelopides panini*)*	critical	Negros-Panay	<1500	3	yes
Rufous-lored Kingfisher (*Penelopides panini*)*	endangered	Philippines	<1000	3	yes
Blue-naped Parrot (*Tanygnathus lucionensis*)	endangered	Philipines	<1000	1	yes
Philippine Hawk-Eagle (*Spizaetus philippensis*)*	vulnerable	Philippines	<2000	2	yes
Java Sparrow (*Padda oryzivora*)	vulnerable	Wider S.E. Asia	<1000	3	no

*dependent on tropical forest habitat, 1 Status from WCSP (1997), 2Geographical distribution and Altitudinal range from Kennedy et al (2000), 3Forest Types: 1) Old growth; 2) Secondary (intermediately disturbed); 3) Secondary regrowth

Table 2. Preliminary inventory of mammal species located within the NNFR. Status from WCSP (1997) and Geographical distribution from Heaney *et al* (1998).

Family	Species	Status	Geographic distribution	Endemic
Cervidae	Visayan Spotted Deer (*Cervus alfredi*)	endangered	Negros-Panay Faunal Region	yes
Suidae	Visayan Warty Pig (*Sus cebifrons*)	endangered	Negros-Panay Faunal Region	yes
Pteropodidae	Philippine dwarf fruit bat (*Haplonycteris fischeri*)	vulnerable	Philippines	yes
	Philippine tube-nosed fruit bat (*Nyctimene rabori*)	endangered	Cebu, Negros, Sibuyan	yes
	Harpy fruit bat (*Harpyionycteris whiteheadi*)	common	Philippines	yes
	Common short-nosed fruit bat (*Cynopterus brachyotis*)	common	Southeast Asia	no
	Musky fruit bat (*Pterochirus jagori*)	common	Philippines	yes
	Lesser long-tongued nectar bat (*Macroglossus minimus*)	common	Southeast Asia	no
Megadermatidae	Common Asian ghost bat (*Megaderma spasma*)	common	Southeast Asia	no
Rhinolophidae	Yellow-faced horseshoe bat (*Rhinolophidae virgo*)	common	Philippines	no
Soricidae	Asian house shrew (*Suncus murinus*)	common	Asia	no
	Oriental house rat (*Rattus tanezumi*)	common	Asia-Pacific	no
	Polynesian rat (*Rattus exulans*)	common	Asia-Pacific	no
	House mouse (*Mus musculus*)	common	Global	no
Cercopithecidae	Long-tailed macaque (*Macaca fascicularis*)	common	Southeast Asia	no
Viverridae	Common palm civet (*Paradoxurus hermaphroditus*)	common	Asia	no
	Malay civet (*Viverra tangalunga*)	common	Southeast Asia	no

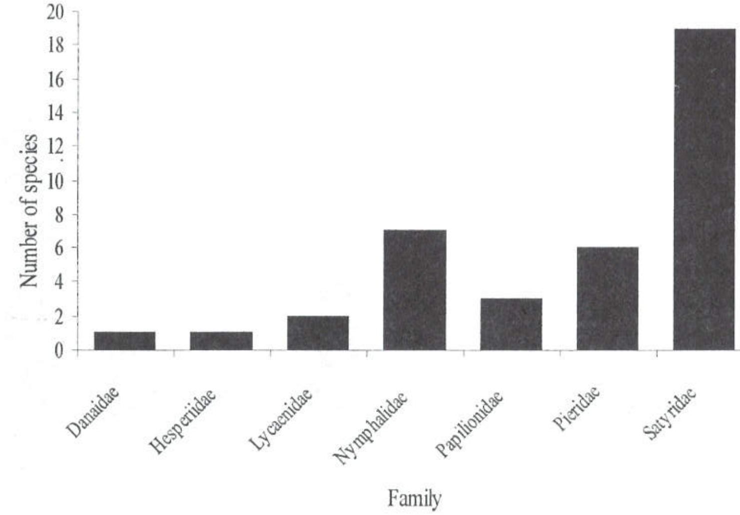

Figure 1. Frequency distribution of butterfly species within families located within the NNFR.

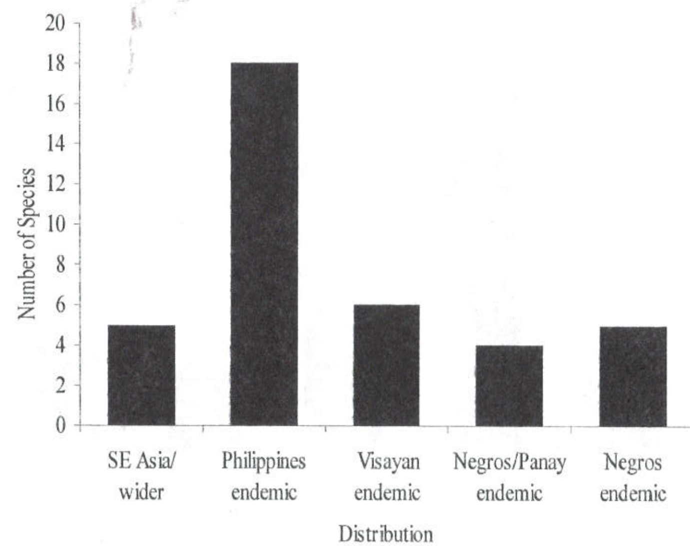

Figure 2. Classification of species identified according to their endemicity/geiographical distribution

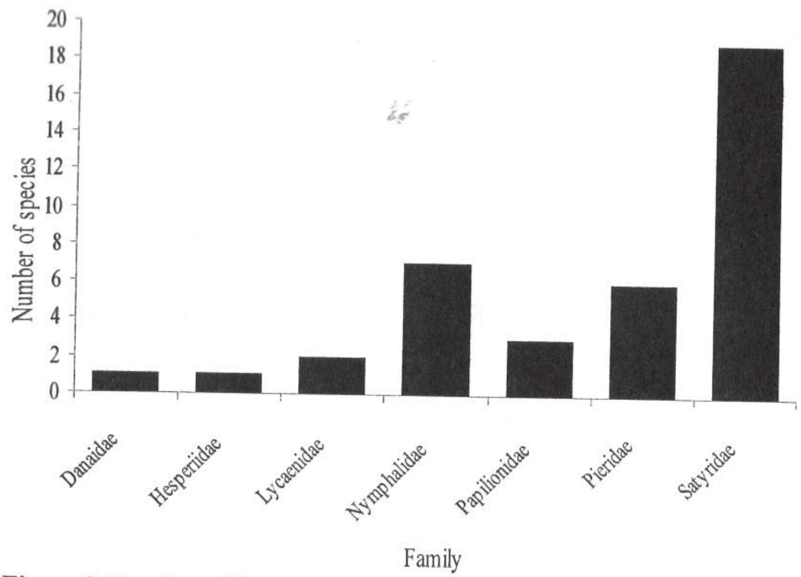

Figure 3. Number of butterfly species by family identified within the NNFR

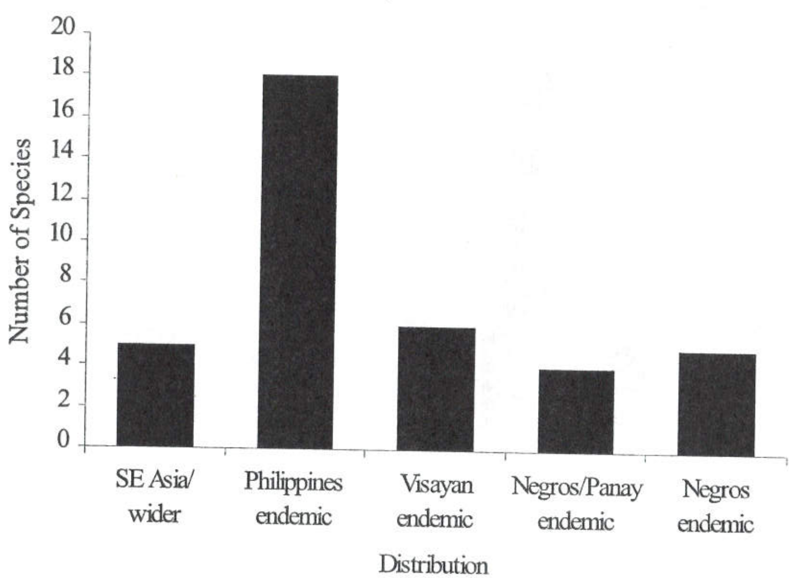

Figure 4. Classification of species identified according to their geographical range

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APPLICATION OF LINEAGE-BASED SPECIES CONCEPTS TO OCEANIC ISLAND FROG POPULATIONS: THE EFFECTS OF DIFFERING TAXONOMIC PHILOSOPHIES ON THE ESTIMATION OF PHILIPPINE BIODIVERSITY

RAFE M. BROWN AND ARVIN C. DIESMOS

"Despite the diversity of alternative species definitions, there is really only one general species concept in modern systematic and evolutionary biology — species are segments of population level evolutionary lineages."
de Queiroz (1998)

ABSTRACT

Appreciation of the magnitude of Philippine amphibian diversity has fluctuated over the past 150 years, with current estimates of diversity owing to progress during five distinct phases in Philippine herpetology. These include: (1) the early taxonomists' period, before the turn of the last century; (2) the career of E. Taylor in the 1920s; (3) the work by R. Inger in the 1950s; (4) the collaboration of A. Alcala and W. Brown between the 1960s and the 1990s; and (5), the current efforts to synthesize and comprehensively review Philippine amphibian diversity in the context of a lineage-based species framework for species recognition.

Until recently, taxonomic studies in the islands have all been conducted in the absence of an explicit species concept or within the context of the Polytypic Species Concept (a variant of the Biological Species Concept). In this paper, we argue that the latter should no longer be applied to Philippine vertebrates because it is a philosophical framework that is not necessarily consistent with evolutionary history. Rather, we suggest the adoption of lineage-based species concepts such as the Evolutionary Species Concept (Simpson, 1961; Wiley, 1978) or The General Lineage Concept (de Queiroz, 1998, 1999) because both of these approaches result in the recognition of taxa in a manner that is logically consistent with known evolutionary history. The geological history of the islands of the Philippines and the known common history of the vertebrates that occupy those landmasses are particularly amenable to interpretation within a lineage-based definition of the species.

Due to the unique geological history of the Philippines and the insular isolation postulated for many of its endemic amphibians, we argue that lineage-based species concepts are the most appropriate approaches for use in taxonomic studies of Philippine amphibians because populations on these islands possess known evolutionary histories and predictable evolutionary fates as deep-water island endemics. Thus, the identification of lineages is straight-forward and can be applied to species groups in a rigorous and repeat-

able fashion. Application of lineage-based species concepts also bolsters more realistic estimates of Philippine biodiversity and should further promote conservation efforts fueled by estimation of species numbers and percent endemicity.

In this paper we review several recent studies that have resulted in significant increases in estimated species numbers within Philippine Amphibia and discuss the historical significance of recent work. Finally, we note several as-of-yet unchallenged polytypic species complexes in the Philippines and suggest various taxonomic groups in need of comprehensive review within the context of lineage-based species concepts.

Introduction

Since the original description of the first species of endemic Philippine frog (Wiegmann, 1834; *Rana vittigera*), the history of amphibian biology of the country has been punctuated with significant incidental collections by early general collectors, and the targeted, dedicated careers of several pioneering herpetologists (see Inger [1954], Taylor [1975], and Duellman and Trueb [1986] for review). The history of Philippine herpetological diversity, like that of most countries, also is a history of disagreement between conservative taxonomists ("lumpers") versus more liberal proponents of species recognition ("splitters"). It is also the history of the discovery of remarkable biological diversity, coupled with the influence of a few charismatic personalities—and how the opinions of a few shaped the manner in which several generations viewed Philippine biodiversity.

Early collectors (Cuming, Everett, Jagor, Mearns, Moellendorff, Semper, and Thompson) sent preserved specimens to European and American museums; these specimens formed the basis of descriptions later published by Boettger, Boulenger, Günther, Mertens, Peters, and Stejneger (Inger, 1954). The age of discovery and description of some of the Philippines most interesting endemic amphibians (1860s through 1910) thus predated the arrival (in 1912) of the father of modern Philippine herpetology: Edward Harrison Taylor.

Taylor (1920–1928, see Literature Cited) recognized a total of 89 species of Philippine amphibians, 42 of which he described as new (one in collaboration with G. K. Noble). Inger (1954) later recognized 55 species of Philippine Amphibia (excluding the recently introduced cane toad, *Bufo marinus*), reducing the species level diversity of Philippine Amphibia by application of the Polytypic Species Concept and by careful re-appraisal of many of Taylor's taxa. Thus some species were relegated to the status of subspecies and others were considered invalid (submerged) and placed in the synonymy of wide-spread SE Asian species complexes (Inger, 1954).

Although recent years have witnessed the discovery of many new species of Philippine amphibians (summaries: Alcala and Brown, 1998, 1999), no systematic effort (e.g., Grismer, 1999) has been undertaken that would comprehensively address Philippine Amphibia in the context of recent philosophical syntheses of species concepts and reconsider the status of Inger's subspecies (Brown et al., 2000). Some investigators have conservatively followed Inger's polytypic taxonomy pending thorough review (e.g., Brown et al., 1996; Alviola et al., 1998; Alcala and Brown, 1998) and others have simply listed Inger's subspecies as full species without comment, justification, or accompanying data (Dubois, 1992; Duellman, 1993; Inger, 1999; Emerson et al., 2000; see comments by Inger, 1996 and Brown et al., 2000; review: Brown, Diesmos & Alcala, this volume.).

The purpose of this paper is to report on the progress towards a case-by-case, lineage-based reconsideration of the diversity of Philippine Amphibia. Between the time that Inger published his review and the present, species concepts have followed the general growth of biological thought towards recognizing and explicitly addressing natural variation and the central theme that evolution plays in taxonomy, classification, and systematics. As such, the recognition of basal units of evolution has turned towards identifying (and naming as species) diagnosable lineage segments that possess recognizable evolutionary pasts and predictable evolutionary fates. In this paper, we attempt to show why this conceptual framework is particularly appropriate when considering the amphibians of the Philippines, largely because of the unique and reasonably well-known recent geological history of the archipelago.

Review of competing species concepts applied in the past to Philippine Amphibia.

Throughout the remainder of this paper we use the term "species concept" to refer to a guiding philosophy or a conceptual framework, and not a practical algorithm, recipe, or a set of rules (criteria for recognizing species). Thus, a species concept is a framework within which sits the notion of what constitutes a species, the basal unit of evolution. Because of the spectacular diversity of life and its history, exceptions to every species-recognition algorithm will exist; as such no recipe is fail-proof for the recognition of all the earth's units of life. Much heat and often very little light has been generated in the process of refutation of one kind of species definition in favor of another (see review in Otte and Endler, 1989; Ereshefsky, 1992; Howard and Berlocher, 1998; Wilson, 1999). Fortunately, recent advances in technology have afforded the taxonomist an expanding set of powerful tools that can be used in place of some of the past's guess work and application of personal opinion. Rather, taxonomy has in some circles become the practice of collection of real data that can be used to test the hypothesis of specificity in a sound and rigorous manner (see Wiens and Servidio, 2000). This technological advance has not arisen unguided. In fact, recent progress in the philosophy of science have advanced the scientific community's understanding of the species concept debate at the same time that several landmark synthesis papers have reviewed the common elements of disparate philosophical viewpoints. The result is a recent consensus in the

literature as to what constitutes and how to identify the units of evolution (review: de Queiroz 1998, 1999). It is our hope that species concept theoreticians can now turn to the task at hand and advance the progress of recognizing the diversity of life unencumbered by excessive philosophical baggage.

Early authors of Philippine amphibian descriptions (Boettger, Boulenger, Günther, Mertens, Peters, Stejneger) were trained at a time when typological philosophy (or "essentialism") dominated biological thought. This general philosophy can be traced to Aristotelian typology and the notion that species are embodied by *types* that are manifest in their truest essence as the "Creator" intended them—by a prototype individual (review: Mayr, 1982). Thus, it has become standard practice for each species to be assigned a holotype specimen. In the past, the holotype was presumed to be the specimen that best embodied what the "Creator" intended for the species. Today, designation of a holotype specimen is still useful for nomenclatural purposes. As a last resort, the holotype is the specimen to which each scientific name applies. In the Aristotelian world view, variation from the essence of a species (as embodied by the *type*) was considered unimportant and inconsequential. When an aberrant specimen that did not conform exactly to the type was inevitably discovered, it was dismissed as a "freak" or a mistake to be ignored, or even discarded (Mayr, 1982). No attempt was made to handle natural variation in species or populations; to an extent, natural variation was even considered troublesome. It was an annoying exception to Aristotelian typology, the philosophy of essentialism, and the notion that God created the perfect form of every species in a pure essence, or *type*.

Charles Darwin published the "Origin of Species" in 1859 but it took several years for the full implications of his and A. R. Wallace's revolution to reach the practitioners of every discipline of biology. Boettger, Boulenger, Günther, Mertens, Peters, Stejneger, and Taylor all published some or all of their descriptions of Philippine amphibians after the advent of the "Origin" (Fig. 1) but each of these workers essentially still followed the practice and unspoken underlying philosophy of typological taxonomy. Thus, many of their species were published on the basis of a single aberrant specimen, and many of those have now been recognized as part of a natural population of variation—possibly at one extreme of the range of that variation, but from within the overall pool of natural variation nonetheless. The slight exception to this trend are some of the later works of E. H. Taylor (1920–1925). Taylor appears to have had a unique and unparalleled understanding, or at least ability to appreciate the products of the evolution of Philippine species because of his personal field work in the country. There are exceptions to everything that can be said in retrospect about any historical character, but herpetologists in general now have an expanded admiration for Taylor's work in the Philippines (e.g., Duellman, 1978). Many of the species he described that were for a time submerged into the synonymy of "widespread" species are now being recognized as valid (e.g., Brown et al., 2000; Brown and Guttman, in press; McGuire and Kiew, 2001); he obviously was a talented field biologist with a sharp eye for variation

With the exception of his memoirs in 1975, Taylor published his last work on amphibians of the Philippines in 1928 and set the stage for the next chapter in Philippine herpetology, the arrival of Robert F. Inger. Inger's comprehensive treatment of Philippine amphibians (Fig. 1) was only the second of its kind ever attempted and his work was based on all previously collected specimens in major museum collections, and additional material gathered by the Philippine Zoological Expeditions of the Chicago Natural History Museum (now the Field Museum) in 1946 and 1947 (review: Hoogstral, 1951; Inger, 1954). His massive contribution took the form of a comprehensive review of Philippine Amphibia

within the framework of the Polytypic Species Concept (PSC). The PSC is a variant of Mayr's Biological Species Concept (BSC), emphasizing the idea that species are populations of interbreeding discrete and discontinuous organisms that often show within-species or interpopulational geographic variation (reviews: Mayr, 1969; 1982; Mayr and Ashlock, 1991). It was the first time that an investigator explicitly adopted a philosophical view of the nature of a species and then systematically applied it to all of Philippine Amphibia and it was the first time that acknowledgement of natural variation, "population thinking", and evolution were considered in the context of Philippine herpetology.

Polytypic species are species characterized by recognizable subspecies, usually in isolated pockets of a species range, or on islands (see comments by Shaffer and McKnight, 1996; Irschick and Shaffer, 1997). The term "subspecies" is thus synonymous with earlier investigators' use of the term "island races" (Inger, 1954) and later researchers' "pattern classes" (e.g. Grismer et al, 1994; Shaffer and McKnight, 1996; Irschick and Shaffer, 1997). Polytypic species in many ways are the result of the revolution of "population thinking." Mayr's BSC has at its heart the requirement of reproductive isolation as the key to recognizing species (Mayr, 1942, 1957, 1969, 1982). During this period most taxonomists conceived of species as widely distributed forms among which gene flow was expected to occur. In the absence of actual genetic studies of gene flow, morphological similarity was often used as a criterion for recognizing conspecific members of a biological species. Diagnosable isolated populations (island races) were assumed to have reduced gene flow with the main population, but by virtue of their similarity, would be expected to easily interbreed should they come in contact with mainland individuals (Mayr, 1982). As such, many island races were described as subspecies with trinomials indicating their status in the rank of hierarchical structure of biological organization.

Robert Inger never traveled to the Philippines himself, and lacked many critical data that are now available to taxonomists (color pattern, behavior, mating calls). His taxonomic decisions were based entirely on preserved museum specimens, many of which were old and poorly preserved (pre-WWII material). Nevertheless, his systematic hypotheses have prompted many later investigations of the amphibians of the Philippines and his 1954 monograph is a classic work of Philippine herpetology that should be considered required reading for students interested in SE Asian herpetology, the Philippines in particular, or biogeography and evolution in archipelagos.

In the mid-1950s, a team of biologists began a lifelong collaboration that continued to the present day. The contributions of Walter Brown and Angel Alcala number somewhere in the 70s and their influence has permeated all taxonomic groups in Philippine herpetology. During the same time, occasionally publishing in collaboration with Dioscoro Rabor and Alan Leviton, the pair systematically reviewed major lizard groups in the Philippines (Brown and Alcala, 1978; 1980, and later published landmark papers on development (Alcala, 1955, 1962; Alcala and Brown, 1955, 1956) reproductive biology (Alcala and Brown, 1982; Brown and Alcala, 1983), population biology (Alcala and Brown, 1967; Brown and Alcala, 1970a), ecology (Brown and Alcala, 1961) and biogeography (Brown and Alcala, 1970b) of Philippine amphibians. They also later published classic reviews on rhacophorid (Brown and Alcala, 1994) and ranid (Brown et al, 1997a, 1997b, 1997c, 1999, 2000; Alcala and Brown, 1998, 1999; Alcala et al., 1998) frog systematics as well (see review in Brown et al., this volume. Their descriptions of numerous subspecies of lizards (Brown and Alcala, 1978; 1980) demonstrate their continued use of the PSC as a general framework for the recognition of diversity, although papers from the last decade have for the most part recognized Philippine

diversity in the form of full species, thus implicitly recognizing species as evolutionary lineages (but see Brown et al., 1999; Alcala and Brown, 1998, 1999).

General concerns: the goals of recent taxonomic studies in the Philippines

In the past five years we have begun the process of attempting to identify and classify species-level lineages of Philippine Amphibia. Our intent is to clarify the status of Philippine amphibian species within the framework of a lineage-based species concept that emphasizes evolutionary history (Wiley, 1978; Frost and Hillis, 1990). The first form of a lineage-based species definition was Simpson's (1961) Evolutionary Species Concept (ESC; see Wiley, 1978, Wiens, 1993, and de Queiroz, 1998, 1999, for review). An evolutionary species is the largest single lineage (ancestor-descendant series of populations) that can be characterized as distinct from other such lineages and within which there is reproductive cohesion (Simpson, 1961; Wiley, 1978; Frost and Hillis, 1990). Although the meaning of what Wiley meant by "cohesion" eludes modern biologists to some degree (Frost and Hillis, 1990; L. Heaney, pers. comm.), the recognition of evolutionary species is the process of identifying (in the thin slice of time that biologists are afforded) the ancestor-descendant series of lineages that have a distinct evolutionary past and those that we expect to have an equally unique evolutionary future. Thus, lineages are any series of ancestor-descendant populations as depicted in a phylogenetic tree, while clades are all composed of all descendant lineages stemming from a single ancestor (Fig. 2).

For our purposes, we consider as distinct lineages segments that are (1) geographically isolated (as montane or insular endemics) and readily diagnosable (by morphology, biochemistry, bioacoustics, and/or ecology) and (2), sympatric, reliably diagnosable forms for which the hypothesis of conspecificity can be confidently rejected (Frost and Hillis, 1990; see also Wiens, 1993). Recently de Queiroz (1998, 1999) reviewed lineage-based species concepts and asserted that by considering speciation as a temporally-extended process one could arrive at a basis of understanding differences between species concepts and species criteria as well as differences between modern definitions of competing species concepts (Fig. 2). De Queiroz (1998, 1999) concluded that most modern species definitions are all aspects or properties of a single common entity and that differences between definitions were not as disparate as the variety of species concepts would suggest. He (de Queiroz, 1998, 1999) suggested the use of the General Lineage Concept (GLC) as the basis for a revised and conceptually unified terminology for resolving the species problem. We have adopted this approach in our recent work.

Lineage-based species concepts as applied to oceanic islands

The key to our understanding and application of the ESC and GLC has been our growing appreciation of the unique geological history of the Philippine Islands (Hall, 1996, 1998) coupled with an understanding of sea level fluctuations during the mid- to late Pleistocene (Heaney, 1985, 1986). It has become abundantly clear that events between the mid- to late Pleistocene have had an enormous impact on the distribution of life in the Philippines (Taylor, 1928; Inger, 1954; Leviton, 1963; Brown and Alcala, 1970; Heaney, 1985, 1986). It is now understood that five to seven major (and several minor) Philippine island groups (complexes of islands separated by shallow channels) intermittently formed much larger land mass amalgamations, the Philippine Pleistocene Aggregate Island Complexes (PAICs). Thus, at various times during the

mid- to late-Pleistocene sea water receded and shallow channel beds were exposed in the form of land bridges connecting smaller islands into larger land masses (Heaney, 1985, 1986; Fig. 3). It is presumed that these events allowed free exchange of fauna and flora via land–positive connections between the otherwise isolated islands of today. Each of the Philippine PAICs (Fig. 3) are now recognized by biogeographers as a kind of faunal subprovince (Taylor, 1928) due to the fact that each supports highly–celebrated suites of endemic taxa (Taylor, 1928; Leviton, 1963; Heaney, 1985, 1986, 1991, 2000; Dickinson, 1991; Peterson and Heaney, 1993; Alcala and Brown, 1998; Kennedy et al., 2000). Most significantly, since we know with certainty the age and history of isolation of amphibian populations on each PAIC, we can conclude with a degree of certainty that the evolutionary history of each lineage is known (e.g., The Palawan PAIC has been isolated from other such land masses and from the edge of the Sunda Shelf for $\geqq$ 165,000 years before present).

Furthermore, since we can assume that for the foreseeable future Pleistocene aggregate island complexes in the Philippines will remain separated (e.g. we expect Palawan PAIC to maintain its isolation from Borneo to the south and Mindoro to the north), we can assert that the evolutionary fate of each lineage is predictable. Combined with careful examination of morphology, biochemistry, behavior, and ecology, it has been a straightforward task to diagnose evolutionary lineages from one another in a reliable fashion. In fact, in most cases, names already exist, as these same lineages have been recognized by typologists on the basis of morphology alone (Taylor, 1920, 1922a, 1922b, 1923, 1925). To date there have only been a few comprehensive reviews of the manner presented above; several others are currently underway (Diesmos, Brown, and Alcala, unpublished data). Application of lineage-based species concepts and expanded data sets to the *Rana signata* and *Rana everetti* species groups in the Philippines has increased Philippine biodiversity in these groups from two to twelve species in total (Brown, 1997; Brown et al., 2000; Brown and Guttman, in press; Table 1; Fig. 3).

The speciation process in the Philippines

While considering species concepts and their implications, it is also important to be explicit about the actual events and underlying evolutionary processes that give rise to current day amphibian diversity. We think of speciation as a process, not an event (de Queiroz, 1998, 1999; Fig. 2). We imagine that dispersal between islands and subsequent isolation, sea level vicariance, and habitat vicariance within islands (i.e., isolation and divergence of montane populations) have all contributed to the process of speciation within Philippine Amphibia (Inger, 1954; Leviton, 1963; Brown and Alcala, 1970; Brown, 1997; Brown et al., 2000). At present there is no evidence that geological vicariance (splitting, breaking apart, or rifting of islands) has occurred in the Philippines but there is evidence to suggest that formerly separate paleoislands have more recently fused together to form some of today's recognizable landmasses (Hall, 1996, 1998).

Due to our assumption that the process of speciation takes time and is not an instantaneous event, it is inevitable that biologists will discover species in the process of diverging. Such potential species may not be fully isolated or diverged from one another, they may show evidence of interbreeding, and as such they may not constitute individual evolutionary lineages. In cases such as this, judgment calls will have to be made; we espouse a conservative approach and caution readers from simply recognizing potential future species without evidence of lineage integrity, a history of isolation,

and the presumption of unique evolutionary fates (see also Frost and Hillis, 1990). Evidence of gene flow, or reticulation, between two potential species suggests to us that neither is a unique evolutionary lineage worthy of specific rank. While we generally do not favor the use of subspecies, the concept of a subspecies as a unique subpopulation (partially isolated from the remainder of the population but exchanging limited gene flow with the main population) is not inherently one to which we object . However, our own recognition of subspecies would have to be contingent upon the demonstration of limited but significant gene flow between a semi isolated deme and a main population of a given species. This would require actual genetic data of the type that is so far lacking in most systematic studies of Philippine frogs (but see Brown, 1997; Brown and Guttman, in press).

Practical considerations and types of data

There has been much discussion of the types of data suitable for the recognition of species (reviews: Otte and Endler, 1989; Ereshefsky, 1992; Howard and Berlocher, 1998). All early investigators and most recent workers have utilized data from external morphology in the form of morphological character and color pattern differences between species (Taylor, 1920; Inger, 1954; Brown et al., 2000), differences in ratios or body proportions (Brown and Alcala, 1994; Brown et al., 1997a-c; Brown et al, 1999, 2000), variation in absolute body size (Alcala and Brown, 1998) and even osteology and live color (Brown et al., 2000). Recent systematic studies have also used information from allozymes (Brown, 1997; Brown and Guttman, in press), biogeography, ecology (Brown et al., 2000), and advertisement calls (Brown et al, 1997b-c, 1999, 2000; Alcala et al., 1998; Brown and Guttman, in press), and molecular sequence data (McGuire and Alcala, 2000; McGuire and Kiew, 2001; Brown, unpublished data).

We are of the opinion that no one type of characters is inherently "better" than any others for species level distinctions and the task of diagnosing lineage-based species. Thus, while some types of studies are better suited (more easily applied, less expensive, more accessible in the Philippines, generally available to all students) to certain studies, there is nothing inherently better about an allozyme, morphological, or color pattern character difference for distinguishing species. Each of these types of data, hopefully reflect evolution, indicate a history of isolation, and serve as convenient or reliably discernable diagnostic characters for the biologist. One fixed character difference between two species is just as good as any other fixed character difference between two species, whether it take the form of an allelic variant on a gel, the presence or absence of asperities on the skin, color pattern differences, the presence or absence of various skeletal elements, dominant frequency of the advertisement call, or microhabitat preferences.

The impact of the application of lineage-based species concepts on the estimated diversity of Philippine Amphibia and a note of caution

As mentioned above, limited use of lineage-based species concepts in our review of Philippine Amphibia has increased species diversity in selected frog groups from two to twelve species in total (Brown, 1997; Brown et al., 2000; Brown and Guttman, in press; Table 1; Fig. 4). For the most part, this exercise has been one of elevating the subspecies of earlier studies to the status of full species in recognition of their status of full, reliably-diagnosable evolutionary lineages with unique pasts and fates. We expect that cautious and conservative application of these principles to Philippine Amphibia will increase the frog fauna of the country by another 20 species at least (Brown, Diesmos and Alcala, unpublished data). Selected species complexes in need of reconsideration (and possible revision) are summarized in Table 2. Even though the practice of reviewing species groups within the context of the GLC has, for the most part, resulted in the simple elevation of the subspecies of earlier studies, we caution the reader from concluding that one could save time and energy simply by systematically elevating all of Inger's (1954) subspecies to full species and arrive at a realistic estimate of Philippine amphibian diversity (e.g., Dubois, 1992; Duellman, 1993; see comments by Inger, 1996; Brown et al., 2000).

First, there has been a major technological advancement of tools for the systematist in the last 48 years, and many data are now available that were not available to Inger at the time of his review. Second, many more specimens are now housed in museum collections than were available at the time of Inger's (1954) review. These specimens represent a wealth of data that must be collected before taxonomic changes should again be made. Third, the past 10 years has seen the discovery of many new species of frogs in the Philippines. Simply elevating Inger's subspecies without careful consideration would not be a realistic way to characterize evolutionary lineages. Fourth, several cases are now apparent to us (Brown and Diesmos, unpublished data) where Inger's subspecies do not correspond to full evolutionary lineages. In these instances, we have concluded that two or more species may actually be contained within a single Inger subspecies and in some cases subspecies will have to be submerged as they correspond to no biologically relevant entity that we are able to detect now that larger samples are available for study (Brown and Diesmos, unpublished data). It is only through careful consideration of all available data on a case-by-case basis (Table 2) that we will be able to arrive at a realistic estimate of the diversity of evolutionary lineages within Philippine Amphibia—and only when this effort is conducted in concert with continued field survey work by trained herpetologists. At present, we recommend the continued use of some of Inger's subspecific taxonomic arrangements until comprehensive reviews are forthcoming. In cases where subspecies have been shown to correspond to distinct evolutionary lineages (e.g., the *Rana signata* and *Rana everetti* complexes), we have elevated these to full species (see Brown, 1997; Brown et al., 2000; Brown and Guttman, in press).

Conclusions

We have argued that lineage-based species concepts are the most appropriate conceptual frameworks for application to Philippine herpetological diversity. We believe that this approach is particularly useful for evaluating specific rank of Philippine Amphibia because of the well known geological history of the Philippines. The isolation of amphibian populations on the separate Pleistocene aggregate island complexes suggests a uniquely recognizable evolutionary past and presumably predictable evolutionary fate. This fact renders taxonomic decisions straightforward and conveniently consistent with evolutionary processes when fixed character states can be found to define and diagnose evolutionary lineage segments (species). Although we demonstrate that expanded appreciation of Philippine

biodiversity can result from application of lineage-based species concepts, we caution the reader from considering elevation of all subspecies to be a fail-proof algorithm for recognizing biodiversity. This is because many exceptions to the patterns of distribution discussed here are known and continue to be uncovered. Only careful, case-by-case evaluation of polytypic species complexes will result in a taxonomy reflective of the evolutionary process of speciation. Only when such an approach is conducted in concert with continued data collection (exploration and field surveys) will the necessary information be gathered. And only in this manner can we recognize and appreciate the full magnitude and unique evolutionary history of the diversity of the amphibians of the Philippines.

Acknowledgments

This paper was developed from ideas initially presented at the 2000 WCSP meeting in Tagaytay City, Cavite, Philippines. We thank the Biological Sciences Department of De La Salle University, Dasmariñas (in particular M. Leonida), for organizing the conference and for inviting us to contribute. We thank A. Alcala, L. Heaney, E. Rickart, G. Pauly, G. Gee, K. de Queiroz, and D. Davison for thoughtful discussions, comments on species concepts, and reviews of earlier drafts of the manuscript. We owe a debt of gratitude to A. C. Alcala and W. C. Brown for their constant support of our work with Philippine amphibians and reptiles.

Table 1. Summary of results of recent taxonomic reviews or systematic analyses bearing on taxonomy of Philippine Amphibia within the context of lineage-based species concepts (e.g., ESC, GLC).

Polytypic species	Subspecies	Current species recognized (range in parentheses)
Limnonectes magnus[1]	*L. magnus magnus*	*L. magnus* (Mindanao PAIC)
	L. magnus acanthi	*L. acanthi* (Palawan + Mindoro PAICs)
	L. magnus macrocephalus	*L. macrocephalus* (Luzon PAIC)
	L. magnus visayanus[1]	*L. visayanus* (Visayan PAIC)
Rana signata[2]	*R. signata similis*	*R similis* (Luzon PAIC)
		Rana sp. (Mindoro PAIC)
	R. signata moellendorffi	*Rana moellendorffi* (Palawan PAIC)
	R. signata grandocula	*R. grandocula* (Mindanao PAIC)
	R. signata signata	*R. signata* (Borneo + Malay peninsula)
		R. picturata (Borneo)
Rana everetti[3]	*Rana everetti everetti*	*R. everetti* (Mindanao PAIC)
	Rana everetti albotuberculata	*R. albotuberculata* (Mindanao PAIC)
	Rana everetti luzonensis	*R. luzonensis* (Luzon PAIC)
		R. igorota (Luzon PAIC, Central Cordillera)
		R. tipanan (Luzon PAIC, Sierra Madres)
		Rana sp. (uncertain)

[1] Philippine populations treated by Emerson and Berrigan (1993) and Emerson et al. (2000) as full species. Other Philippine species in this group include Limnonectes diwatus and Limnonectes new species (unpublished data). The status of L. acanthi on both the Mindoro and Palawan PAICs is suspect and in need of review.
[2] Philippine populations last reviewed by Brown (1997) Brown and Guttman (in review). This species complex also contains Rana melanomenta (type specimens destroyed) and Rana siberu (Mentawi islands, Indonesia).
[3] Philippine populations last reviewed by Brown et al., 2000

Table 2. Selected Philippine polytypic species in need of review, and the major Pleistocene Aggregate Island Complexes (PAICs), constituting their geographical distribution.

Polytypic species	Subspecies	Range in the Philippines
Bufo biporcatus[1]	*B. b. philippinicus*	Palawan PAIC
Megophrys monticola[1]	*M. m. stejnegeri, M. m. ligayae*	Mindanao PAIC; Palawan PAIC
Occidozyga laevis[1]	*O. l. laevis*	throughout the Philippines
Rana cancrivora[1]	*R. c. cancrivora*	throughout the Philippines
Rana limnocharis[1]	*R. l. vittigera*	throughout the Philippines
Limnonectes microdiscus[1]	*L. m. leytensis*[2], *L. m. palawanensis*	Mindanao + Visayan PAIC; Palawan PAIC
Rana nicobariensis[1]	*R. n. nicobariensis*	Palawan PAIC
Nyctixalus pictus[3]	*N. p. pictus*	Palawan PAIC
Polypedates leucomystax[3]	*P. l. leucomystax*	throughout the Philippines
Rhacophorus everetti[3]	*R. e. everetti*	Palawan PAIC
Kaloula conjuncta[1]	*K. c. conjuncta, K. c. negrosensis,*	Luzon + Mindoro PAICs; Visayan PAIC;
	K. c. meridionalis, K. c. stickeli	Mindanao PAIC; Mindanao PAIC

[1] Philippine populations last reviewed by Inger (1954)
[2] See also Emerson et al. (2000)
[3] Philippine populations last reviewed by Brown and Alcala (1994)

Fig. 1.— The relationship between the cumulative total of recognized Philippine Amphibia and the year of each species (lineage's) description. Only currently recognized species were included in this figure.

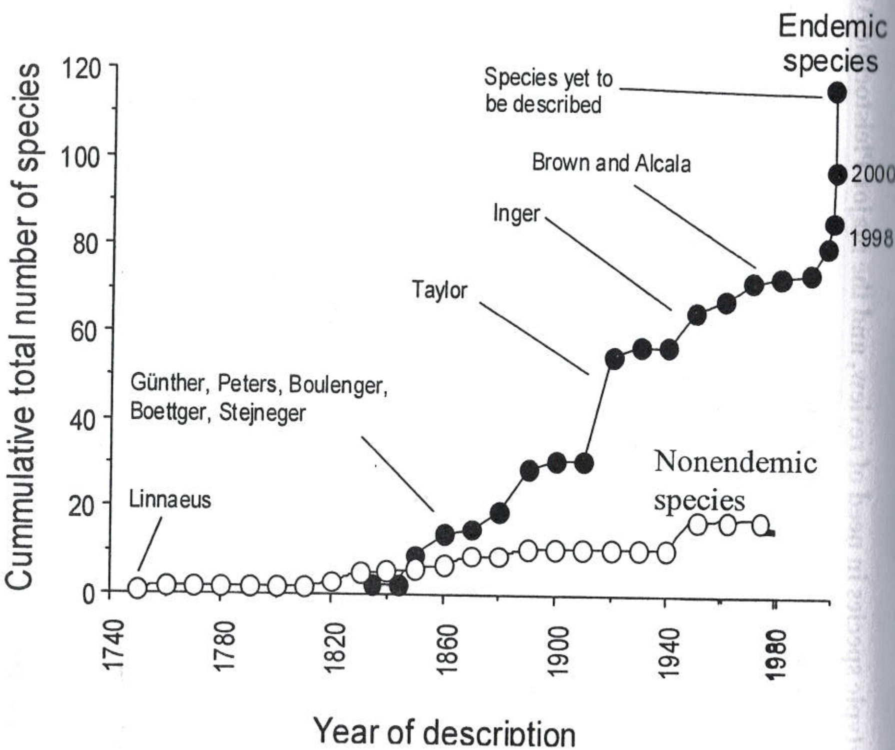


Fig. 2.—Clades versus lineages and the speciation process. The nine branching diagrams (A and B) represent the same phylogeny, with various clades emphasized in part A and some of the possible lineages emphasized in part B. Speciation and criteria for the recognition of species (C): the set of events constituting the process of speciation may be considered by different workers as the basis of recognizing the two species at various levels of divergence, isolation, or accumulation of diagnostic or apomorphic characters. Adapted from de Queiroz (1998), with permission.

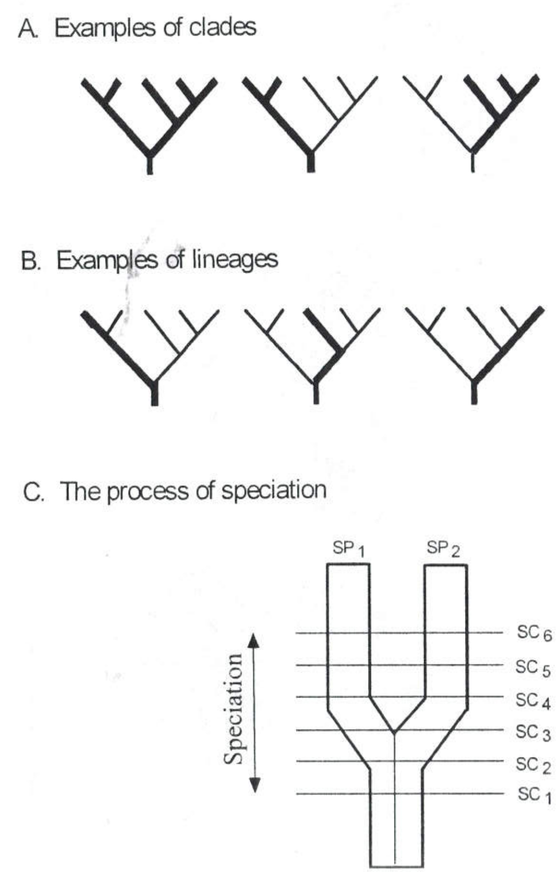


Fig. 3.— Zoogeographical classification of the Philippines into major Pleistocene Aggregate Island Complexes (PAICs) in recognition of the 120 underwater bathymetric contour and known mid- to late-Pleistocene sea level reductions (following Heaney, 1985, 1986).

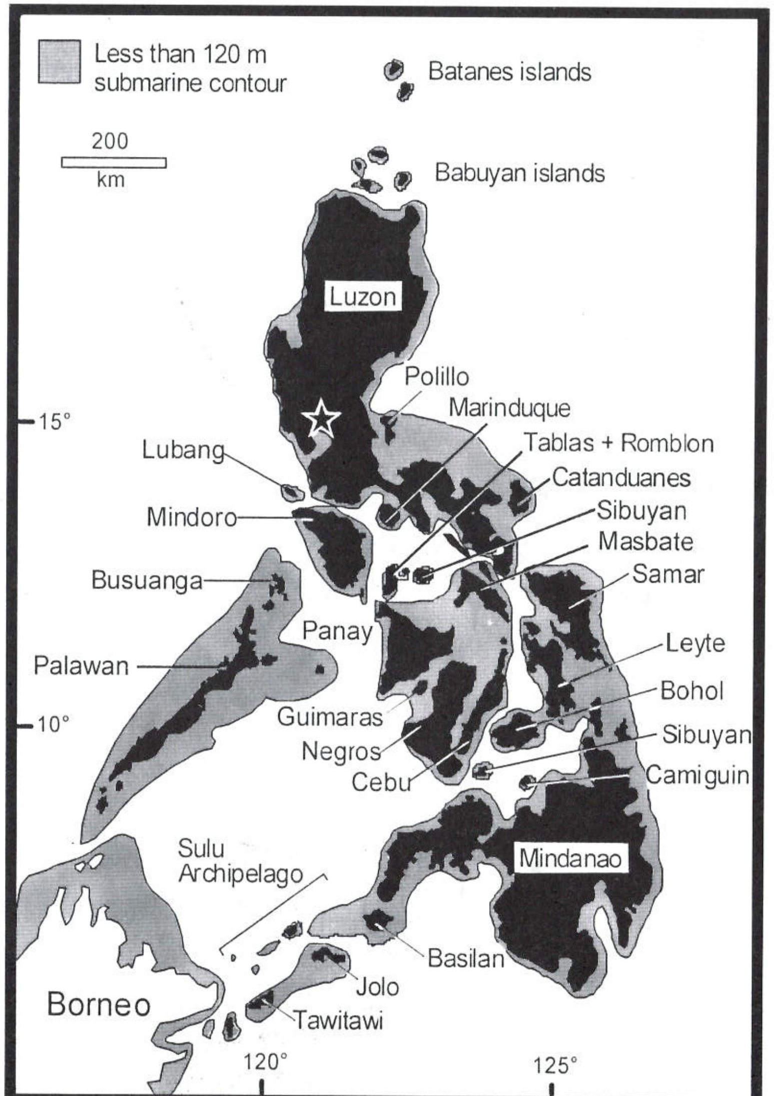


Fig. 4.— Representative Philippine species of the *Rana everetti* and *Rana signata* species complexes. See Brown (1997; Brown and Guttman, in press) and Brown et al. (2000) for review.

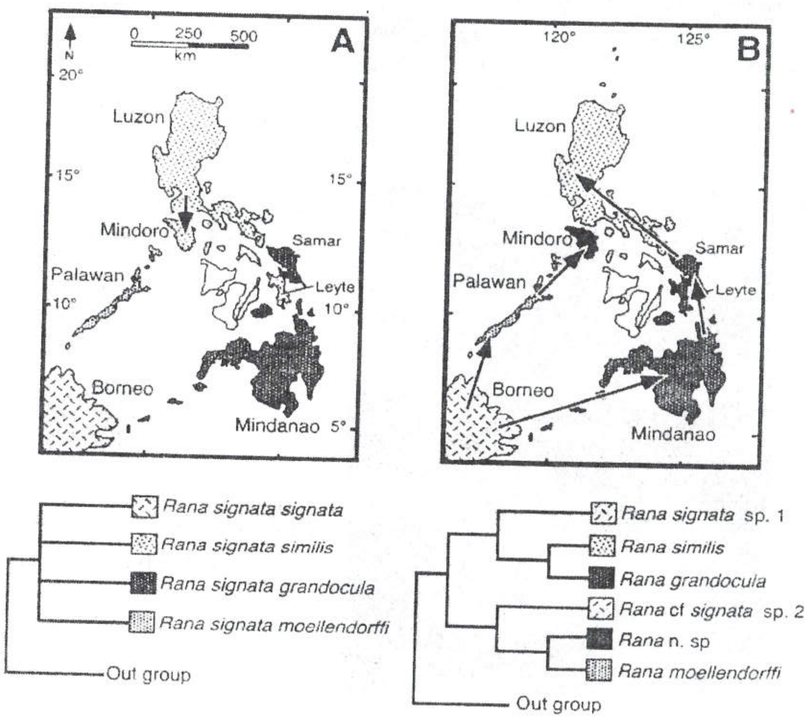
Rana grandocula
(photo: R. Brown)

Rana moellendorffi
(photo: R. Brown)

Rana luzonensis
(photo: R. Brown)

Rana tipanan
(photo: J. McGuire)

Fig. 5 -- Alternative interpretations of the *Rana signata* complex and its distribution in Borneo and the Philippines. Previous taxonomic interpretations (A; Inger, 1954) considered each insular lineage in the Philippines to be subspecies of the widely distributed polytypic *R. signata* (this taxonomy provided no phylogenetic resolution of relationships) and the Mindoro and Leyte populations were considered conspecific with the Luzon subspecies (*R. signtata similis*). In contrast, morphology, acoustical analyses of advertisement calls, biogeography and geological information, and the phylogeny for the group suggests that all Philippine populations previously considered subspecies should be recognized as full species in accordance with their status as independent evolutionary lineages (Brown and Guttman, in press). These six lineages are divided into two major clades, consistent with the hypothesis of two invasions of the Philippines from Sundaic sources. Thus the common ancestor of the *R. signata* clade may have given rise to *R. grandocula* and *R. similis* by faunal exchange eastward into the Sulus-Mindanao-Leyte-Samar-Luzon arc while the ancestor of the *R.* cf *signata* sp. 2 clade may have given rise to *R. moellendorffi* and *R. mangyanum* by faunal exchange along the Palawan-Busuanga-Mindoro arc (note arrows, B).



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AUTECOLOGY AND THE CONSERVATION OF INSECTIVOROUS BATS ON MT. MAKILING, PHILIPPINES

JODI L. SEDLOCK

ABSTRACT

The diversity and community ecology of an insectivorous bat community on Mount Makiling, Philippines was studied over the course of 17 months between June 1997 and August 1999. Bats were inventoried acoustically using a library of call signatures, through roost searches, and captured using mist nets, a harp trap, and a tunnel trap. Foraging behavior with respect to habitat type and resource abundance was determined through both systematic sampling of acoustic bat activity and insect abundance along transects, and at resource patches (stream pools) during explicit time intervals in the night. This paper provides a summary of the salient information on habitat use, diet, foraging mode, reproductive timing, and roosting preferences gleaned from these data with respect to 22 species of insectivorous bats encountered on Mount Makiling. Additionally, I consider how coexistence mechanisms which maintain local bat diversity, such as habitat selection and the partitioning of resource abundance, may break down in the face of habitat disturbance and loss.

Introduction

Insectivorous bats represent the most poorly known, and possibly most threatened, group of mammals in the Philippines (Heaney et al. 1998, Heaney and Regalado 1998). A combination of agility, slow and maneuverable flight, and use of echolocation have allowed insectivorous bats to evade the mist nets of field researchers for decades. Nevertheless, 43 species have been documented, 10 of which are endemic to the archipelago (Ingle and Heaney 1992, Heaney et al. 1998). However, new endemic species of murids and pteropodids—two groups for which sampling has been relatively intensive—continue to be described today (Heaney et al. 1998, Gonzales and Kennedy 1996), suggesting that this may be only the tip of the iceberg. Use of novel capture devices such as harp traps, and the acoustic monitoring of species-specific echolocation calls have been successful in documenting the diversity and ecology of similar species in Malaysia (Francis 1989; Kingston et al. 1997, 1999, 2000), Papua New Guinea (Bonaccorso 1998) and Australia (Law et al. 1999). New inventory protocols incorporating these and other methods will help fill this gap in the Philippines.

With respect to ecological information, however, Microchiropterans are not far behind other mammal groups. Fruit bats are by far the most studied mammals in the Philippines. Intensive research has been conducted on their foraging ecology (Utzurrum 1995), microhabitat use (Ingle 1993), population biology (Heideman and Heaney 1989), reproductive ecology (Heideman 1989, Heideman et al. 1993), and most recently their role in forest regeneration on the forest edge (Ingle unpub. dissertation). The population ecology of murid rodents, in contrast to our relatively extensive knowledge of their distribution and taxonomy (e.g. Musser 1981, Musser and Heaney 1992, Heaney and Rickart 1990), is known from only one intensive study on Mt. Isarog (Balete and Heaney 1997). Until now, no intensive study had been conducted on insectivorous bat ecology in the Philippines. Knowledge of the basic ecological requirements of species is becoming increasingly important as the focus of conservation strategies in the Philippines expands from delineating protected areas to monitoring the animals within them (Danielson et al. 2000). Research which yields complete site inventories of insectivorous bats and ecological data useful in monitoring and conservation planning is needed.

This study represents a step towards this goal. The objectives of this paper are to i) augment the preliminary data of Ingle

(1992) on the diversity and natural history of insectivorous bats on Mount Makiling, ii) summarize some of the first detailed information available on their foraging and roosting behavior, and iii) discuss the implications of these data for the conservation, management, and monitoring of Philippine insectivorous bat communities.

Methods

Between June and August 1997, and again between June 1998 and August 1999, I studied the diversity and ecology of insectivorous bats on Mount Makiling, Laguna Province, Philippines (Sedlock in press). Mt. Makiling is volcanic in origin and reaches approximately 1115 m at its highest peak. The forest reserve covers approximately 42.44 km^2, but only about 25 km^2 is covered in either natural forest or plantation forest (Cruz et al. 1991). Mount Makiling is typical among Protected Areas in the Philippines in that it is comprised partly of secondary rather than primary lowland rain forest; also, the forest lies at high elevations on a volcanic mountain surrounded by a mixture of agricultural forest, grasslands, and other crop lands. Mt. Makiling is mildly seasonal, with a dry period between January and April (Pancho 1983). The average daily temperature and humidity during the 14 months of this study (measured at the base of the mountain) was 27.7 ° C. and 83.7%, respectively. The average annual rainfall, also measured at the base of the mountain, is 1990 mm. During my field season, the majority of rain fell between the months of June and November, with several typhoons hitting the study site in September/October 1998 and July 1999.

I collected data using a variety of methods, including i) random captures using mists nets, a harp trap, and tunnel trap (Sedlock in press); ii) systematic sampling with a bat detector of acoustic activity along transects in forest, agro-forest, and along a creek (Sedlock 2001); iii) systematic sampling of acoustic activity at insect patches such as stream pools and streetlights (Sedlock 2001); iv) random acoustic sampling; and, v) roost searches by random inspection of rock crevices, tree hollows and caves; tracking bat flight patterns and interviews with local residents, hunters, and gatherers. Voucher specimens were deposited at The Field Museum of Natural History, Chicago.

Results and Discussion

Species accounts

We captured and/or acoustically encountered 22 species of insectivorous bats on Mount Makiling. Table 1 includes all captured species, and provides the range and sample sizes for standard measurements useful in species identification. Each species account contains two sections. In the first, I address species' habitat preference and foraging behavior gleaned either from netting and trapping data, acoustic monitoring along habitat transects, and fecal analysis. In the second, I characterize any day-roosts we encountered, and compare these to previous roosting data reported in the Philippines as well as other portions of its range. Reproductive data are provided throughout each account with respect to individuals captured within their foraging habitat or at day roosts.

Emballonura alecto (Eydoux & Gervais)

Emballonura alecto occurs throughout the Philippine archipelago (Heaney et al. 1998), and in Borneo and Sulawesi (Corbet and Hill 1992). As this species is rarely captured in mist nets, little is known of its foraging behavior and habitat use. On Mount Makiling, the virtual absence of acoustic encounters along forest and creek transects, although this species possesses a detectable and distinct call (Sedlock 2001), suggests that it forages above the forest canopy. However, it

should be capable of foraging within the forest vegetation, as its wing morphology indicates relatively slow, maneuverable flight (Sedlock 2001). Similarly sized species of the genus *Emballonura* in Papua New Guinea forage by hawking and gleaning insects within the understory or tree fall gaps (Bonaccorso 1998).

I encountered two rockfall roosts along forested creeks occupied by *Emballonura alecto* on Mount Makiling. The smaller roost housed only 10-15 bats. The larger of the two (approximately 5 m long, 3.5 m high, and 3 m wide) contained more than 100 bats. In response to disturbance, all of the bats burst out of the roost and circled high in the forest subcanopy at mid-day. After about 15 minutes, most of the bats entered another rock-fall cave less than 50 m away from the original roost. These roosts are similar to those previously reported on Makiling (Ingle 1992), and at other sites in the Philippines (Rickart et al. 1993; Heaney et al. 1991, 1999). Generally, they seem to prefer dimly-lit caverns which afford them a wider range of roosting opportunities than many cave-roosting species. In the Philippines they have been found primarily in rock crevices, rock falls, and at the entrance of larger caves. In Borneo small groups have also been found under the buttresses of fallen tree trunks (Payne et al. 1985).

On Mount Makiling, we captured one lactating female in early August. Ingle (1992) captured six pregnant females in the same roost in April of 1989, and a lactating female in June of the same year. Similar reproductive timing was documented on Leyte and Maripipi Islands, with pregnant females caught during March and April and lactating and juveniles encountered during July (Rickart et al. 1993).

Megaderma spasma (Linnaeus)

Megaderma spasma is the only representative of the family Megadermatidae in the Philippines, but it is widespread throughout the archipelago with the exception of the Batanes/

Babuyan region (Heaney et al. 1998). On Mount Makiling, we netted two adult males in secondary lowland forest on 16 June 1997. The bats seemed to be foraging together as they hit the mist net simultaneously. *Megaderma spasma* uses prey-generated cues, rather than echolocation, while foraging (Tyrell 1988). As such, I could not monitor its foraging activity acoustically. However, previous capture records of *Megaderma spasma* are mostly from lightly disturbed and primary lowland forests, and montane forests (Heaney et al. 1991, Ingle 1992, Lepiten 1997, Rickart et al. 1993, Heaney et al. 1999). It possesses short, broad wings affording it slow, maneuverable flight in spite of its large size (Table 1) allowing it to forage effectively in the relatively dense forest understory. On Mount Makiling, *Megaderma spasma* primarily consumes noise-producing prey, such as gryllid, tettigonid orthopterans, and cicadid homopterans (Balete 1988).

We located one *Megaderma spasma* roost in a large tree hollow beside a road in secondary forest (350 m). On 12 June 1998, six bats occupied the roost, and on 15 August 1998 the tree housed eight bats. The entrance opened at the base of the tree, and was approximately 0.7 m high and 0.6 m wide. The ceiling of the hollow rose 4 m off the ground. Balete (1998) monitored two groups of *Megaderma spasma* on Mount Makiling; one in a tree hollow (n = 4 - 7), and another in a small cave (n = 5). Ingle (1992) located six additional tree hollow roosts containing one to seven bats on Makiling, all with openings at ground-level or 1.5 m high.

Hipposideros ater (Templeton)

Though wide-spread throughout the Philippines and Southeast Asia (Heaney et al., 1998; Koopman, 1989), little is known of *Hipposideros ater*'s habitat preferences since it has only been collected from cave roosts (Rickart et al. 1993, Heaney et al. 1991). On Makiling, a harp trap captured five individuals foraging low along a forest trail at the forest edge,

and a tunnel trap captured two *H. ater* foraging over a small forest stream (Sedlock 2001). *Hipposideros ater* possesses low intensity, high frequency calls (132 kHz), which are difficult to detect with a bat detector at a distance (Sedlock 2001). Nevertheless, I acoustically detected and visually observed several individuals circling low over grasses in the agro-forest at the forest edge together with *H. obscurus* and *R. virgo*. From these modest data, it is not possible to assess the effect of habitat disturbance on individual foraging behavior or subsequently, the population's status. I suspect that given its slow, maneuverable, continuous flight and preference for moths (Sedlock 2001, Bonaccorso 1998, Pavey and Burwell 2000), *H. ater* would be reliant on the forest to some degree. Individuals identified as *H. ater* in Australia have been classified as forest specialists, as they seem to avoid forest gaps (Crome and Richards 1988).

Two identical man-made tunnels perched high on a limestone wall served as roosts for more than 500 *Hipposideros ater* individuals on Mount Makiling. Each tunnel extended approximately 20 m straight into the mountain. Two-thirds of the way in, two chambers (6 m long) opened on either side, such that the floor plan resembled a cross. The ceiling was only 0.7 meters high and just as wide, forcing one to crawl when entering the cave. We made two visits, once on 19 March 1999 and again on 21 June 1999. In March , we captured four adult males, five pregnant and three non-pregnant, adult females from the cave. In June, we encountered only juveniles (n = 10) and lactating females (n = 10). When we entered the cave, we found solitary juveniles and groups of nursing mothers down each of the "arms" of the tunnel. *Hipposideros ater* shared the cave with a much smaller number of *Rhinolophus macrotis* individuals (approx. 30) which occupied the deepest part of the tunnel. Heaney et al. (1991) found a smaller *H. ater* colony (30-40) in a slightly larger cave on Catanduanes Island, and Rickart et al. (1993)

found a small group in a smaller rockfall shelter on Maripipi Island, Philippines (Rickart et al. 1993). Moderately sized colonies utilizing dark caves have been reported across its range (Bonaccorso 1998, Flannery 1995, Kitchener et al. 1990, Payne et al. 1985). Additionally, Bonaccorso (1998) reported on solitary individuals and small groups roosting in hollow trees and the undersides of large boulders.

Hipposideros diadema (É. Geoffroy)

Hipposideros diadema is the largest insectivorous bat in the Philippines, and appears to be flexible in its habitat use and foraging mode. It ranges from Burma to the Solomon Islands, and throughout the Philippines (Heaney et al. 1998). On Makiling, *H. diadema* biased its activity towards riparian and agro-forest habitats, although it utilized the forest as well. Most authors have identified *H. diadema* exclusively as a perch-hunter, sallying off a perch to capture passing insect prey (Brown and Berry 1983, Bonaccorso 1998, Flannery 1995, Pavey and Burwell 2000). On Mount Makiling, *H. diadema* utilizes this energy-efficient foraging mode later in the night when insect abundance declines, but also hawks for insects in the open air (Sedlock 2001). At dusk, when insect abundance is highest, we observed aggregations of individuals (2-10 individuals) foraging just over the agro-forest canopy and high above the canopy in the open air. Switching foraging modes in response to resource availability and structural contexts (aerial hawking may not be fruitful among vegetation due to high wing loading) affords *H. diadema* a broad range of habitats and resource abundances on which it can forage profitably. Its diet of large Hemiptera and Coleoptera (Sedlock 2001) accords with diets of individuals in Australia (Pavey and Burwell 1997) and Paupa New Guinea (Bonaccorso 1998). Additionally, the diet of Makiling bats includes swarming insects such as termites and winged ants, resulting from the exploitation of rich insect patches early in the night

(Sedlock 2001).

We did not locate any roosts used by *H. diadema* on Makiling, although we did capture several individuals commuting along a wide trail just below a large rock outcrop where we discovered a cave housing three species of *Rhinolophus* (see *Rhinolophus arcuatus* account). It is possible that another cave is in the vicinity, or that it occupies the same cave but utilizes a different (larger) exit. Nevertheless, large maternity colonies of *Hipposideros diadema* in caves are well documented in the Philippines and across its range (Rabor 1986, Bonaccorso 1998). We captured two pregnant and one lactating female, and one juvenile on 15 and 20 July 1999. On Leyte, Rickart et al. (1993) caught a pregnant female on 28 March, and on Siquijor Island, Lepiten (1995) caught a pregnant female in April.

Hipposideros diadema uses a short (15-20 milliseconds), constant frequency (68 kHz) call with a prominent FM terminal sweep. The only species with a call of similar frequency is *Rhinolophus arcuatus*; however, it can be distinguished from *H. diadema* based on its comparatively long duration (80 ms) and short FM sweep at both the start and end of the pulse (Sedlock 2001).

Hipposideros obscurus (Peters)

Hipposideros obscurus is a Philippine endemic, but wide-spread and common throughout the archipelago (Heaney et al. 1998). We acoustically detected this species foraging in the forest understory, over forest streams, as well as on the forest edge in an agro-forest. Ingle (1992) caught two individuals on Makiling in secondary forest. At other sites, it has also been captured in both disturbed and primary lowland forest, from 250 to 740 m (Heaney et al. 1991, 1999; Rickart et al. 1993; Lepiten 1995). It seems to forage exclusively in continuous flight, in contrast to similarly sized rhinolophids (e.g. *Rhinolophus arcuatus*) which switch between "fly-catching" and aerial hawking (Sedlock 2001). *Hipposideros obscurus*' diet consists of a broad range of insects (n = 4 four individual samples), including scarab beetles, click beetles, moths, termites, ants, lygaeid bugs, and flies (Sedlock 2001).

Unlike *Hipposideros ater* and *H. diadema, H. obscurus* does not appear to form large colonies, or at least none has been found. On 20 June 1998 and again in August, we found groups of two and five individuals roosting in two separate culverts under an old logging road in second-growth lowland forest. We observed their emergence on one night. The bats emerged just after dark (around 1820 h), and then over the next two hours, flew in and out of the roost, and by 2100 h all bats had returned. In February, we found two individuals roosting in a small (.4 x .5 m), dark compartment in the back of a larger, shallow cave (approximately 6 m deep, 10 m wide and 1.4 m high). One was an adult male, and the other evaded capture. We captured two lactating females over Pili Creek on 15 August 1998, and another on 15 July 1999. An adult female captured in February 1999 was neither pregnant nor lactating. Ingle (1992) captured juveniles on Makiling in July 1989.

Hipposideros obscurus uses a short duration (9 milliseconds), high frequency (116 kHz) call. It is easily distinguished from other bat calls on Mount Makiling, but difficult to detect from a distance due to high attenuation rates (Sedlock 2001).

Rhinolophus arcuatus (Peters)

Rhinolophus arcuatus has been captured throughout the archipelago (Heaney et al. 1998), and seems more common in the Philippines than in other parts of its range (Bonaccorso 1998, Payne 1985). On Mount Makiling, *R. arcuatus* biases its foraging activity towards the forest, but also exploits adjacent agricultural habitats (Sedlock 2001). We rarely encountered it foraging in riparian habitats. At other sites in the Philippines it has also been captured in disturbed forest, but more frequently in primary lowland and montane forest up to 1350 m (Heaney et al. 1991, Rickart et al. 1993). It forages throughout the night among moderately cluttered understory vegetation. *Rhinolophus arcuatus* uses both aerial hawking and "fly-catching" foraging modes, but is less likely to be encountered perch-hunting than the larger *R. inops*. It is also less likely to use the same foraging perch on subsequent nights than *R. inops* (Sedlock 2001). Its diet consists primarily of small scarab beetles and moths, but also termites, ants, leaf hoppers, lygaeid bugs, and flies (Sedlock 2001).

In June 1998, we found a large maternity colony of *Rhinolophus arcuatus*, *R. inops* and *R. virgo* at 675 m in natural second-growth lowland forest on Mount Makiling. We found the cave after capturing > 100 bats in mist nets set across a ravine approximately 300 m below the roost in July 1997. Unfortunately, we could not inspect the inside cavern as the openings stood 4 m off the ground and the rocks proved unstable. The main exit was < 1 m high and wide, and the secondary opening, approximately half the size of the first, served mainly as an entrance. Bamboo and vines created a dense, concealing matrix in front of the roost, which all three species expertly negotiated in fast flight. The first bat (*R. virgo*) emerged at 1805 h, and the emergence continued until 2004 h. We did not attempt to formally estimate the population size, but it seemed that more than 5,000 bats occupied the cave. We recorded the emergence using an Anabat II bat detector on two nights. *Rhinolophus arcuatus* emerged first, accompanied by occasional bursts of *R. virgo*. By 1823 h, a continuous stream of *R. arcuatus* and *R. inops* emerged from the largest exit. Between 1843 h - 1900 h, both species continued to emerge, but only intermittently. At 1906 h, *R. inops* began to increase in number, until it was the most common bat emerging at 1945 h. At 2011 h the first bat returned to the roost.

We captured bats exiting the roost on 5 August 1997, 29 June 1998 and again on 28 June 1999. During June we caught 22 *R. arcuatus*. Of the 16 adult females, 10 were pregnant, four were lactating and two were neither pregnant nor lactating. The remaining six of 22 were juveniles caught emerging from the roost much later than the females (0145 h).

Rhinolophus arcuatus uses a long (80 ms) constant frequency call at 71 kHz that is intense and easily detected with a bat detector at a distance (> 10 m). Juveniles may use a slightly lower frequency than adults (68 kHz), which overlaps with the CF of *Hipposideros diadema*. However, *H. diadema*'s call has a shorter in duration (15 ms) and has only a terminal FM sweep (Sedlock 2001).

Rhinolophus inops (K. Andersen)

Rhinolophus inops is an endemic, wide-spread species in the Philippines (Heaney et al. 1998). On Mount Makiling, we frequently encountered *Rhinolophus inops* acoustically in the lowland forest and adjacent agro-forest, but rarely in riparian habitats. These data contrast with netting records in which *R. inops* was not common in secondary, disturbed forest (Heaney et al. 1998, Rickart et al. 1993). However, it is unclear how far from the edge of intact forests it will forage. *Rhinolophus inops* possesses high wing loading, making it a fast flier. This, along with the high transport costs associated with large body size and short, broad wings, makes "fly-catching" an effective foraging strategy. *Rhinolophus inops* prefers perch hunting, and does not switch foraging strategies in response to changing resource abundances as *H. diadema* does (Sedlock 2001). The same hunting perches may be used repeatedly over 2-5 nights; however, we could not verify that it was the same bat on the perch each night. Moreover, *R. inops* prefers perching sites above the understory in less cluttered sites than the smaller *R. arcuatus* (Sedlock 2001).

Its diet consists primarily of beetles, but also moths, termites, ants, lygaeid bugs, and flies (n =12 individuals). *Rhinolophus inops* consumes significantly more beetles than the smaller *R. arcuatus* (Sedlock 2001).

Rhinolophus inops shared the large roost previously described (see *Rhinolophus arcuatus* account) with *Rhinolophus arcuatus* and *Rhinolophus virgo*. On 29 June 1998, it began emerging from the roost after *R. arcuatus* (1824 h), and continued to exit until 1945 h. During two separate visits in June, we caught nine pregnant females, two lactating, and one juvenile. The juvenile emerged from the roost much later (2314 h) than the majority of adults. In August 1997, we caught three adult males, two females neither pregnant nor lactating, one lactating female, and four juveniles. Rickart et al. (1993) caught pregnant females in March and April on Leyte, and Ingle (1992) captured 13 lactating females on Mount Makiling near their maternity roost in July 1989.

Rhinolophus inops uses a long duration (80 ms) CF call between 54-56 kHz. *Rhinolophus macrotis* possesses a CF call of similar frequency (51-53 kHz), but does not overlap with that of *R. inops* (Sedlock 2001).

Rhinolophus macrotis (Blyth)

Rhinolophus macrotis is not currently recognized as an endemic species. Philippine individuals, however, are distinct from those on mainland China and Malaysia (Ingle and Heaney 1992, Heaney et al. 1998). Extremely elusive and difficult to capture, *R. macrotis* remains poorly known. Mist nets, a harp trap, and the tunnel trap all failed to capture it. Nevertheless, the paucity of acoustic encounters with *R. macrotis* (n = 64) relative to *R. arcuatus* (n = 318) and R. *inops* (n = 132) on Mount Makiling—despite its intense, easily distinguished call—suggests that it may be less abundant (Sedlock 2001). Alternatively, this inequity in encounter frequencies could indicate a difference in foraging mode. Its large ears may permit passive listening to locate prey; the less frequently *R. macrotis* uses echolocation, the less probable it is to be detected. We did observe it flying slowly in circles close to the forest floor on two occasions, but never witnessed it in the act of gleaning insects. *Rhinolophus macrotis* allocated its foraging effort among habitats in a similar manner to other *Rhinolophus* species. It allocated its activity equally between the lowland forest (total passes = 31) and agro-forest (total passes = 27), but rarely foraged over the creek (total passes = 6). Only four of 64 total encounters represented perched bats.

We found *Rhinolophus macrotis* roosting together with *Hipposideros ater* in two man-made tunnels (see *H. ater* account for description). *Rhinolophus macrotis* represented a small proportion of the bats in each roost (< 10%). They segregated themselves from *H. ater*, and occupied the deepest part of the tunnel. On 21 June 1999, we caught nine individuals exiting the roost, eight adult males and one pregnant female.

Rhinolophus rufus (Eydoux and Gervais)

Rhinolophus rufus is endemic to the Philippines, and remains poorly known (Heaney et al. 1998). We did not capture *R. rufus*; however, Ingle (1992) captured one individual on Mount Makiling in 1989. *Rhinolophus rufus* possibly uses a lower call frequency than the other *Rhinolophus* species, since it is much larger (Bogdanowicz et al. 1999). I recorded two unidentified rhinolophid-like calls (i.e. constant frequency, long duration), one at 31 kHz and another at 45 kHz, either of which could belong to *Rhinolophus rufus*. Only five 31 kHz call passes were recorded, two in second-growth lowland forest (450 m), one in an agro-forest (50 m), and one along a forested stream (375 m). I recorded the two 45 kHz passes in an agro-forest (50 m) near the forest edge. Therefore, if either of these calls do indeed belong to *R. rufus*, it is rare. These are high intensity, low frequency calls which travel with minimal attenuation Therefore, encounter biases resulting

from call detection cannot account for these low pass frequencies. *Rhinolophus rufus* is thought to roost in caves, although Heaney et al. (1991) observed several individuals perched in a shallow rock overhang on Catanduanes Island. Also, there have been accounts of colonies in a large cave in southeastern Luzon (P. Alviola, personal comm.). Further studies on its foraging behavior and population biology are needed.

Rhinolophus virgo (K. Andersen)

Rhinolophus virgo is endemic to the Philippines and thought to be widespread throughout the archipelago (Heaney et al. 1998). On Mount Makiling, it actively foraged in lightly disturbed lowland rain forest and the adjacent agro-forest (Sedlock 2001). The majority of foraging activity in the agro-forest occurred at the forest edge early in the evening, so it may be more sensitive to forest disturbance than the activity data indicate. The absence of *R. virgo* at the more disturbed sampling site (50-200 m) further suggests a strong affinity for intact forest. We observed it foraging in small groups of 2 - 3 individuals in the forest understory, circling for several minutes in one area before moving on. Also, we frequently observed it foraging in groups with *Hipposideros ater* and *H. obscurus* in the agro-forest at the forest edge (400 m) before dark. Only one of 86 *R. virgo* passes represented a perched bat. Therefore, it appears that *R. virgo* hunts primarily by continuous aerial hawking. The low frequency of encounters (total passes = 86) relative to *R. arcuatus* (total passes = 318) and *R. inops* (total passes = 132) may be a result of detection biases rather than lower abundances. *Rhinolophus virgo* uses a high frequency call (85 kHz), which attenuates much more quickly than those emitted by other *Rhinolophus* species.

On Mount Makiling we found *Rhinolophus virgo* roosting in a variety of locations. The largest group of individuals occupied the roost described earlier (see

Rhinolophus arcuatus account) along with *R. arcuatus* and *R. inops*. *Rhinolophus virgo* represented a small proportion of the roost inhabitants (< 5%). Nevertheless, it appeared that at least 100 individuals emerged from the roost intermittently between 1804 h and 1940 h on 28 June 1998. On the same night, we captured six pregnant females, three lactating, and one neither pregnant nor lactating. We captured no males. On 5 August 1997, we caught three individuals about 250 m from the roost, one pregnant female, one female neither pregnant nor lactating, and an adult male. Culverts under an old logging road through second-growth forest served as day roosts for many *R. virgo*. *Hipposideros obscurus* also used these culverts as roosts, but never shared culverts with *R. virgo*. Generally, we encountered one to six individuals occupying a single culvert. On 21 January 1999, three of the seven available culverts were occupied by single males. Five days later, we captured all six bats occupying one culvert roost. It appeared to be a harem, consisting of one adult male and five adult females. The male was slightly smaller and used a lower call frequency (83 kHz) than the females (86-87 kHz), although generally males and females did not differ in size (forearm lengths; $F_{1,31} = 0.047$, $P = 0.83$). Nevertheless, sexually dimorphic calls may serve a social function in mating and foraging. Individuals seem to move between culverts. An adult male I marked on 12 June 1998 was re-captured in a different culvert on 16 June 1998. We found a single bat perched in a rockfall cavern near Dampalit Creek (460 m), an indiviual perched on the underside of a large boulder near the large rhinolophid roost, and a bat perched in the hollowed buttressed root system of two balete (*Ficus* sp.) trees—one along Pili Creek and the other in second growth forest about 250 m from Pili Creek

Kerivoula whiteheadii (Thomas)

Kerivoula whiteheadii ranges from southern Thailand,

through Borneo and the Philippines (Heaney et al. 1998). All of the species in the Family Kerivoulinae are poorly known in the Philippines. The individual we captured on Mount Makiling represents only the second specimen from Luzon Island; the first was collected in Isabela Province (Heaney et al. 1998). In Peninsular Malaysia and Australia, harp traps have recently added new records (Kingston et al. 1997) and ecological information (Schulz and Wainer 1997, Kingston et al. 1999) on *Kerivoula* species. Species in the family Kerivoulinae use low intensity, high frequency, short duration, broad-band calls (Kingston et al. 1999) rendering them very difficult to detect with a bat detector at even short distances, and highly capable of detecting the fine threads of a mist net. On Mount Makiling, we caught one juvenile male *Kerivoula whiteheadii* with the tunnel trap over a pool of a small stream. Upon entering the tunnel trap, the bat flew very slowly close to the water surface circling around my legs. Despite its slow flight, it managed to evade my sweep net for several minutes before I captured it. In a large enclosure, I observed it hover around the bases of trees and fly slowly close to the ground. When it perched on the enclosure wall made from netting, it did not hang as most other bats did, but curled into a ball with its head upright. *Kerivoula whiteheadii* possesses the lowest aspect ratio and wing loading of all Mount Makiling species, affording it slow and highly maneuverable flight adaptive for foraging among dense clutter. In Australia, *Kerivoula papuensis* forages on sessile prey, primarily spiders (Schulz and Wainer 1997). Therefore, while previous accounts of this species in the Philippines come from disturbed forest and agricultural areas (Sanborn 1952, Heaney et al. 1998), I suspect that *Kerivoula whiteheadii* frequents intact forest. Use of harp traps in the Philippines may greatly and rapidly increase our understanding of this and other *Kerivoula* species.

Miniopterus australis (Tomes)

Miniopterus australis is wide-spread, ranging from India to Australia and throughout the Philippines (Heaney et al. 1998, Koopman 1989). We did not capture *M. australis* on Mount Makiling. However, we suspect that it is quite common there, based on frequently recorded echolocation calls (FM, F_{min} = 61 kHz) matching the calls used by *M. australis* in Australia. Moreover, we caught *M. schreibersi* and *M. tristis* on Mount Makiling, species commonly found inhabiting large cave roosts with *M. australis* (Heaney et al. 1991, Rickart et al. 1993). Assuming that these calls belong to *M. australis*, on Mount Makiling, it biased its activity toward riparian habitats and the open air (Sedlock 2001). The highest activity along sampling transects occurred between 2200 h and 0000 h on Molawin Creek (50 m). We also recorded it foraging above the canopy in an agro-forest (375 m), and around streetlights on the University of the Philippines campus and along forested roads (350 m). It was never recorded along forest transects.

We did not locate *Miniopterus australis* day roosts on Mount Makiling; however, virtually all previous Philippine records come from cave roosts (Heaney et al. 1991, Rickart et al. 1993). The size of colonies reported from the Philippines (< 100) pale in comparison to those in Australia, where over 100,000 bats occupy a single cave. Dwyer 1968 and Strahan 1983 reviewed the roosting ecology of *M. australis* in Australia. Systematic cave surveys would contribute to our understanding of the distribution and ecology of this species in the Philippines.

Miniopterus schreibersi (Kuhl)

Miniopterus schreibersi has a broad distribution from Europe to the Solomon Islands (Heaney et al. 1998). We caught nine individuals with the tunnel trap, representing the first records of *M. schreibersi* on Mt. Makiling. In March 1999, we caught four adult females and two adult males foraging

around a streetlight along a forested road between 2100 h and 2300 h (300 m). In June, we captured one lactating female and an adult male flying along Pili Creek at 2300 h and 2100 h, respectively. Also in June, we caught an adult male flying along a forested road at 2210 h. *Miniopterus schreibersi* is an extremely flexible forager, which may contribute to its success in temperate and tropical habitats. It has a high wing loading and aspect ratio relative to smaller forest understory vespertilionids (e.g. *Myotis muricola*, *Pipistrellus* spp.) rendering it a less maneuverable flier, but providing it fast, energy-efficient travel (Sedlock 2001). On Mount Makiling, it is one of the most common species exploiting the rich streetlight-generated insect patches along a forested road (350 m), and consumes primarily moths and termites (Sedlock in prep. d). On Mount Isarog, Heaney et al. (1999) caught two adult males foraging around a fluorescent light at 1450 m, and Rickart et al. (1993) caught *M. schreibersii* along a road in montane forest at 700 m on Leyte. Therefore, despite its association with forest habitats, it may require fly-ways within the forest to forage. Perhaps the opening of many forests with trails and roads has contributed to its success in tropical regions. Similar patterns of microhabitat use have been reported in Australia (McKenzie and Rolfe 1986) and Indonesia (McKenzie et al. 1995).

We did not locate the day roosts of *Miniopterus schreibersii* on Mount Makiling. However, it is known to occupy caves throughout the Philippines (Heaney et al. 1998, 1991; Rickart et al. 1993), and forms very large colonies in other portions of its range (Dwyer 1966, Strahan 1983).

Miniopterus tristis (Waterhouse)

Miniopterus tristis has been recorded in Sulawesi and the Philippines (Corbet and Hill 1992, Heaney et al. 1998). In March on Mount Makiling, we caught one adult female, neither pregnant nor lactating, in the tunnel trap while it foraged around a streetlight, and we caught one adult male foraging along Molawin Creek in June. These represent the first records of *M. tristis* in Laguna Province. Like *Miniopterus schreibersi*, I frequently recorded it foraging around streetlights and occasionally encountered it foraging along forested streams and roads. *Miniopterus tristis* possesses the highest wing loading among the species captured on Mount Makiling, and as such makes it the fastest, least maneuverable flier. The two individuals I captured had consumed beetles and moths (Sedlock 2001). We did not locate their day roost on Makiling, but the species has been recorded in caves (Rickart et al. 1993, Flannery 1995).

Murina cyclotis (Dobson)

Murina cyclotis occurs from Sri Lanka to Hainan and Borneo (Heaney et al. 1998). It has been recorded throughout the Philippines, and is thought to be moderately common. As with many insectivorous bats, I suspect that *M. cyclotis* is more common in Philippine forests than indicated by prior faunal inventories. We caught a pregnant female in March and an adult male with scrotal testes in July. A mist net set at ground level along a forest trail caught the female, and similarly, a net set along a stream bank caught the male. In the last case, the bat actually escaped from the mist net and fortunately flew into the tunnel trap. Unlike many insectivorous bats, *Murina cyclotis* does not seem to follow fly-ways (e.g. trails, streams, roads) and as such, is more likely to be caught in nets set parallel rather than perpendicular to trails and streams. However, Kingston et al. (1999) caught 22 individuals in Peninsular Malaysia using four-bank harp traps set across forest trails. The most distinctive aspect of its foraging behavior is its use of the dense understory just above the forest floor. *Murina cyclotis* has been recorded in disturbed and primary forest from 50 to 850 m on Leyte (Rickart et al. 1993), in montane forest up to 1500 m in Luzon (Ruedas et al. 1994), and heavily disturbed forest on Siquijor Island (Lepiten 1995). Its diet has not been studied, although a similar species, *Murina florium*, feeds on beetles and spiders (Schulz and Hannah 1998). In Malaysia, *Murina cyclotis* uses a low intensity, short duration (2.4 millisecond) call starting at 165 kHz and ending at 51 kHz (Kingston et al. 1999). The combination of high frequency and low intensity prohibited me from detecting *M. cyclotis* along transects (and even in hand!) with the Anabat II system. As such, the use of harp traps may be the best strategy for improving our understanding of *Murina cyclotis'* relative abundance across elevational and disturbance gradients. The roosting habitats of *M. cyclotis* are unknown in the Philippines, but there are accounts of *Murina* species roosting among clusters of dead leaves, caves, and in scrubwren and fernwren nests (Schulz and Hannah 1998, Nowak 1994).

Myotis horsfieldii (Temminck)

Myotis horsfieldii ranges from southeastern China through the Malay Peninsula, Sulawesi and is thought to be moderately common in the Philippines (Heaney et al. 1998). *Myotis horsfieldii* represented the most frequently caught species during my field season on Mount Makiling. We caught 63 bats along forested creeks — 34 adult males, and 27 females. We caught pregnant females in May (n = 4) and April (n = 1), lactating females in June (n = 2) and July (n = 1), and two juveniles also in July. Females are slightly, but significantly larger than males based on forearm length (mean FA_{male} = 35.4 mm, n = 34; FA_{female} = 36.2 mm, n = 27; $F_{1,59}$ = 13.12, P=0.001). The majority of captures occurred early in the evening during the first hour after dark; however we captured many individuals in the tunnel trap between 2000 h and 0000 h as well (n = 15). The acoustic activity data confirmed a strong bias towards riparian habitats (855/863 passes) and yielded a similar temporal activity pattern as the trapping data. *Myotis horsfieldii*'s activity peaked early, declined rather abruptly, and then rose again slightly around midnight. Its diet consists of (in decreasing order) caddisflies, termites, winged ants, moths, beetles, and flies (n = 17 individuals). Over the course of the night, diet breadth of individuals widens as they exploit only rich patches of caddisflies and termites early in the night, expanding later as insect abundance declines. Short duration, broad-band calls and relatively long wingspans allow *Myotis horsfieldii* to forage close to the water and detect emergent insects against the water surface. On Mount Makiling, *Murina cyclotis* and *Kerivoula whiteheadii* are also capable of this foraging strategy, but their smaller size and slower flight may render them less competitive at such rich insect patches. Payne et al. (1985) also observed *Myotis horsfieldii's* affinity for waterways in Borneo, and observed it roosting in crevices and caves near water. In the Philippines, *M. horsfieldii* had been reported to roost in caves, tunnels and on the underside of large rocks (Heaney et al. 1998, Taylor 1934).

Myotis muricola (Gray)

Myotis muricola ranges from Afghanistan to New Guinea, and is common throughout the Philippines (Heaney et al. 1998, Corbet and Hill 1992). We captured only five individuals, but recorded acoustic activity frequently and over a wide range of habitats. In July, four bats were caught along Pili Creek (375 m), and among these was a lactating female. In September at 2200 h, we hand-caught a juvenile female perched on a low vine (0.4 m) hanging over a forest trail at 400 m. It appeared to be resting after a foraging bout. Its fecal pellets contained winged ants, beetles, and moths (Sedlock 2001). Activity data along habitat transects showed that *Myotis muricola* was most active on higher elevation creeks (> 200 m) early in the evening, and then moved into the forest and agro-forest later in the night (Sedlock 2001). It responded to

rich insect patches, but not as strongly as other small vespertilionids (i.e. *Myotis horsfieldii* and *Pipistrellus* spp.). For example, we infrequently encountered it foraging around streetlights where *Miniopterus* spp. were abundant. Along forest trails, we frequently observed solitary foragers circling in forest gaps or in the open subcanopy. Previous accounts of *M. muricola* on Makiling and other regions of the Philippines have also noted its apparent abundance in the forest understory from 50 m to 1500 m in lowland and montane forest (Ingle 1992, Rickart et al. 1993, Ruedas et al. 1994, Heaney et al. 1999). Ingle (1992) caught individuals in mist nets between 0.5 m and 9.5 m above the ground in the forest. Its roosting habitats are unknown in the Philippines, although it is known to roost in furled leaves of banana plants in Borneo (Payne et al., 1985). On Mount Makiling, *Myotis muricola*'s echolocation call is easily distinguished from that of other species (FM, Fmin = 52 kHz), and is similar to recordings made of conspecifics in Peninsular Malaysia (T. Kingston, pers. comm.).

Philetor brachypterus (Temminck)

Philetor brachypterus ranges from Nepal to New Guinea, and occurs throughout the Philippines (Heaney et al. 1998). On Mount Makiling, we caught one pregnant and two lactating females in the tunnel trap in July 1999. They flew fast and straight down the creek before they collided with and clung to the netting at the back of the tunnel. They made no attempt to escape in flight. Rather, they tried to crawl out of reach, but generally were easily taken by hand. This behavior, in conjunction with a very high wing loading and aspect ratio, suggests that *Philetor brachypterus* is not a capable flier among obstacles. However, in August 1998 at around 2230 h, we did capture an adult male within second-growth forest in front of the rhinolophid roost described previously (see *Rhinolophus arcuatus* account). It is not clear if the individual emerged from the rock wall, or was only foraging there. Also on Mount Makiling, Ingle (1992) captured two *Philetor brachypterus* in nets 7 m off the ground above the understory vegetation. Also, on Leyte (Rickart et al. 1993), Mount Isarog (Heaney et al. 1999), and even in Papua New Guinea (Bonaccorso 1998) it occurs in rain forests, occasionally venturing out into agricultural areas (Bonaccorso 1998). Therefore, it seems that *Philetor brachyterus* is most active in the sub-canopy, where the vegetation is not dense, and along riparian habitats. Among understory species on Mount Makiling, it may be superior at finding and exploiting ephemeral, rich insect patches. Fecal pellets of two individuals contained either 100% termites or winged ants, suggesting that they had foraged on insect swarms (Sedlock 2001). There are no data on the roosting habits of *Philetor brachyterus* in the Philippines. In other parts of its range up to 55 individuals have been reported to roost in tree holes 1.5 to 4.5 m above the ground (Bonaccorso 1998, Payne et al. 1985).

***Pipistrellus javanicus* (*Pipistrellus* sp. A and B)**

The taxonomy of species belonging to the *Pipistrellus javanicus* group are still poorly understood in the Philippines. Differences in skull morphology among specimens collected throughout the Philippines originally identified as *Pipistrellus javanicus* suggest that two species are represented , but their identities are currently uncertain (LR Heaney, pers.comm.). I captured two species *P. javanicus* on Mt. Makiling, and for the sake of discussion, I will refer to them here as *Pipistrellus* sp. A and sp. B. *Pipistrellus* sp. A is lightly smaller than B (Table 1), and its pelage is a dark rufus-brown on the dorsum and venter. *Pipistrellus* sp. B is bicolored , with dark rufus-brown pelge on its dorsum and lighter rufus pelage on its venter. The call used by *Pipistrellus* sp. B is slightly lower than that of *Pipistrellus* sp. A; nevertheless, broad inraspecific variation exhibited by both species prevented me from

distinguishing among them in the filed (Sedlock 2001).

Based on acoustic activity, they biased their activity towards Molawin Creek early in the night, and then appeared to spread out into the agro-forest and forest, especially at the higher elevation site (450 m) later in the night (Sedlock 2001). In addition to the creek, they exhibited high activity along the forest edge and around the crowns of emergent trees. During random acoustic sampling at higher elevations (600 - 1000 m), we frequently encountered small groups of *Pipistrellus* spp. foraging low in small forest gaps, and high in the open subcanopy of riparian forests. Moreover, while activity does peak early over the creek, these acoustic data clearly showed that *Pipistrellus* spp. remain active throughout the night. For example, on one night, individuals foraged over our camp at 650 m from 1815 h to 2230 h, and in the morning I recorded them from 0440 to 0530 h.

We caught a total of 19 *Pipistrellus* sp. A. In June and July 1999, we caught four adult males and four adult females along Pili or Molawin Creeks. In April, we caught two lactating females foraging along Molawin Creek at 2300 h. We caught nine juvenile *Pipistrellus* sp. A in May and June, six along a forested road (between 2230 and 0030 h), and two along Molawin Creek (between 2100 and 2000 h). The apparent communication between juveniles was impressive. After placing one bat in a cloth bag, we observed that other bats responded almost immediately to its social calls. In fact, one bat hovered so close to the bag that we caught it by hand. We caught seven *Pipistrellus* sp. B, all on Molawin Creek, between April and June 1999. In April, we trapped two pregnant females, and in May and June, four lactating females and an adult male. The fact that we captured *Pipistrellus* sp. B exclusively on Molawin Creek, and *Pipistrellus* sp. A on both Pili and Molawin, suggests a difference in elevational preferences. Perhaps the smaller *Pipistrellus* sp. A, being more maneuverable and possessing a higher call frequency, can forage more efficiently on low insect abundances which characterize high elevations than the larger *Pipistrellus* sp. B. Generally, *Pipistrellus "javanicus"* is thought to prefer montane forest, and be less common in lowland and mossy forests (Heaney et al. 1998, 1999; Payne et al. 1985). My analysis of fecal samples revealed virtually identical diets between species. Both consumed a wide range of insects, including moths, winged ants, leaf hoppers, lygaeid bugs, termites and beetles (Sedlock 2001). The roosting habits of *Pipistrellus javanicus* are poorly known in the Philippines. On Mount Banahao, southeast of Mount Makiling, a solitary bat identified as *P. javanicus* was found roosting in the dead trunk of a coconut tree (AC Diesmos, pers. comm.). In Borneo it has been reported to roost in the thatched roofs of houses (Payne et al. 1985).

Scotophilus kuhlii (Leach)

Scotophilus kuhlii is a common and wide-spread bat, ranging from Pakistan to Taiwan and Bali (Heaney et al. 1998). In the Philippines, this might be the most familiar insectivorous bat to people in towns and cities. It forages over ricefields and around street and house lights at dusk. Moreover, they commonly roost in buildings in huge colonies, although they also roost in tents made from modified palm fronds (Rickart 1989, Rickart et al. 1993). On Mount Makiling, we caught one lactating female foraging around a streetlight on the University of the Philippines, Los Banos campus. In July, we netted one adult male, six lactating females, and eight juveniles exiting an attic roost in Los Banos. *Scotophilus kuhlii* is not a rain forest species, and as such, benefits most from forest degradation and urbanization. Its diet consists of termites, beetles, winged, ants and large lygaeid bugs (Sedlock 2001). Generally, individual diet samples consisted of one insect type, indicative of the exclusive exploitation of rich insect swarms. As a fast and agile flier, *Scotophilus kulhii* may be a superior competitor at such patchily distributed and ephemeral resources.

Foraging behavior, mechanisms of coexistence, and the conservation of insectivorous bat diversity in the Philippines

A thorough site inventory of insectivorous bats has never been conducted in the Philippines, not even on Mount Makiling. Therefore, assessing the impact of habitat loss and disturbance on species diversity through comparative studies of species richness across sites is not possible (e.g. Zubaid 1993, Law et al. 1999, Brosset et al. 1996, Estrada et al. 1993, Schulze et al. 2000). Differences in an animal's behavior across a disturbance gradient may offer a tangible alternative. Moreover, understanding how species coexist within intact forest may help us predict the impact of particular types of disturbance (e.g. habitat reduction, loss of structural complexity on species at the community level. Equipped with this knowledge, one can make an argument for the preservation of the environmental context which supports the greatest bat diversity, independent of one's knowledge of the particular species there. In the following discussion, I will use the behavioral data summarized above to assess the relative tolerance of individual species to local habitat disturbance on Mount Makiling. Then, I will use Mount Makiling's lowland insectivorous bat community as a model to apply what I have learned about mechanisms of coexistence (Sedlock 2001), to assess the potential impact of habitat reduction and disturbance on local bat diversity in a more abstract sense.

My field sites on Mount Makiling and the lowland forest habitats sampled within them, encompass different levels of disturbance and provide an opportunity to assess the effect of habitat alteration on species' foraging behavior. Particularly, the extent to which species utilized the agricultural forests may be indicative of their tolerance for habitat disturbance. All eight species I was able to monitor acoustically along habitat transects foraged in the agro-forest, including *Rhinolophus arcuatus*, *R. inops*, *R. virgo*, *Hipposideros diadema*, *Myotis horsfieldii*, *M. muricola*, *Miniopterus australis* and *Pipistrellus* spp. Relative to their activity in the forest and creek, *Myotis muricola*, *Pipistrellus* spp., *H. diadema*, and *R. inops* displayed the highest activity in the agro-forest. These species capitalized on the high insect abundance outside the forest, particularly early in the night. For example, *H. diadema* used aerial hawking to exploit rich insect swarms within the agro-forest, but switched to perch-hunting when foraging within the forest. Furthermore, these data indicate that *R. arcuatus* and *R. virgo* (because most agro-forest activity was concentrated on the forest edge) are most intolerant of altered forest habitats. Nevertheless, it seems that replacing grasslands with agro-forests near the forest edge may create opportunities for both people and bats. However, despite the benefits of citrus trees and coconuts over grasslands, these data in no way suggest that agro-forests alone could support current bat diversity. I would argue that the natural mechanisms promoting diversity lie within the forest.

Within the forest on Mt. Makiling, microhabitat selection, resource partitioning and spatial and temporal partitioning of insect abundances provided mechanisms of coexistence for insectivorous bat species (Sedlock 2001). Therefore, habitat disturbance affecting vegetation structural complexity, insect diversity or insect abundance in space and time could—over time—reduce species diversity in predictable ways. For example, reduction of habitat complexity through understory clearing (e.g. collection of firewood, rattan, palms) and selective logging may increase competition between small, forest-living aerial insectivores of the families Rhinolophidae and Vespertilionidae. *Rhinolophus virgo* has a competitive edge over *Pipistrellus* spp. when foraging in cluttered forest micro-habitats due to its echolocation design. Conversely, in the absence of

vegetational complexity, *Pipistrellus* spp. would be the superior competitor and may exclude *R. virgo* over time. Among the vespertilionids, *Kerivoula* and *Murina* seem to coexist with *Myotis* spp., *Pipistrellus* sp. and *Philetor* through microhabitat partitioning, although simplification of the forest understory may not intensify competition between these groups as intensely as in the latter case. *Kerivoula* and *Murina* would still be superior competitors near the ground (e.g. gleaning). However, reduction in ground vegetation may increase predation risk for these slow, hovering bats.

Processes which alter insect diversity and abundance, such as fragmentation as well as disturbance of the forest interior, may greatly affect species whose coexistence depends on resource partitioning and partitioning of insect abundances. For example, Lepidopteran diversity and abundance is associated with host plant diversity (Brown and Hutchings 1997). As such, *Hipposideros ater*, a moth specialist, may suffer from a decline in moth abundance associated with vegetation loss. Generally, though, bats are not specialists on particular insect taxa, therefore changes in species composition, (not richness, e.g. Didham et al. 1998b) associated with disturbance is not the problem *per se*. Rather, bat species specialize on certain insect attributes such as size, hardness, evasiveness, and behavior (i.e. swarming versus dispersed), the reduction in heterogeneity of insects with respect to these attributes could increase competition among bat species. And, indeed, insect diversity does decline with increasing magnitude and time since disturbance (Bolger et al. 2000, Didham 1997, Didham et al. 1998a, Brown and Hutchings 1997). For example, *Rhinolophus arcuatus*, *R. inops* and *Hipposideros diadema* all consumed scarab beetles, but seemed to partition them by size (Sedlock 2001). Alternatively, species whose coexistence depends more on resource patchiness than diversity (e.g. *Philetor brachypterus*, *Pipistrellus* spp. and *Myotis muricola*) may benefit from disturbance as many insects respond with increased abundance in forest gaps or on the forest edge (e.g. Scarabaeidae, ants; Didham et al. 1997).

Forest disturbance through clearing and selective logging practices can limit roosting opportunities for bats by reducing suitable tree holes (Tidemann and Flavel 1987) and by removing foraging habitat adjacent to cave roosts. Most bat species on Mount Makiling appear to have flexible roosting requirements, although a number of species appear to require relatively large caves as maternity roosts during part of the year (April - August; i.e. *Hipposideros ater*, *H. diadema*, *Rhinolophus arcuatus*, *R.inops*, and perhaps also *R. virgo* and *R. macrotis* and *R. rufus*). Other species may require caves throughout the year, including *Miniopterus schreibersi, M. australis,* and *M. tristis*. In temperate (Humphery 1975) and tropical (Arita 1995) regions, cave availability can strongly influence local bat diversity. I suspect that the majority of small to moderate-sized cave roosts utilized by species in continuous forest are cryptic and undisturbed. However, the majority of large, low-elevation caves in the Philippines are heavily disturbed by tourism, guano mining, and hunting. Large cave roosts, particularly if they are in, or adjacent to, forest can house multiple species of bats and should represent a conservation priority in the Philippines. Arita (1995) found that in Mexico, species diversity within caves varied in a nested fashion. The largest caves contained the most, and the most rare species, while smaller caves housed only a few common species (Arita 1995). A nation-wide faunal cave survey is badly needed in the Philippines in order to identify where (and if) these conservation opportunities still exist. As for species reliant on tree holes (i.e. *Megaderma spasma, Philetor brachypterus, Kerivoula whiteheadii* and perhaps *Rhinolophus rufus*), the conservation of primary forest and the natural succession of trees within those forests is imperative.

Therefore, with respect to the known insectivorous bat species on Mount Makiling, I believe that *Rhinolophus macrotis* and *Rhinolophus rufus* are of special conservation concern. *Rhinolophus macrotis* exhibited low activity based on acoustic encounters despite its easily detected call, and intensive acoustic sampling effort. Similarly, the calls potentially belonging to *Rhinolophus rufus* were fewer than I would expect based on detection biases. Moreover, both species may be reliant on caves as maternity roosts within forest. Interviews with local residents and hunters lead us to a number of unoccupied caves, where they claimed guano collection had once occurred. The accessibility of the forest on Mount Makiling and the resources available at the adjacent University of the Philippines in Los Baños provide an ideal opportunity for radio-tracking studies which may assist in locating roost sites, determining habitat requirements, and making population estimates of *Rhinolophus rufus*. Populations of other species rarely encountered on Mount Makiling, such as *Kerivoula* spp. and *Murina cyclotis*, are quite likely healthy—but difficult to monitor. An intensive harp-trapping study on Makiling could yield reliable abundance estimates, and valuable ecological data for further assessing their conservation status.

The work I conducted on Mount Makiling represents the most thorough effort to understand the local diversity and ecology of microchiropterans undertaken thus far in the Philippines. However, the forest on Mount Makiling is atypical for the Philippines, and such, may not provide the best model for bat communities in the country generally. Makiling is partially covered by secondary tropical lowland forest (between 50 to 1000 m), whereas montane to mossy primary forest (approx. 1000 m to 2000+ m) characterize the majority of remaining— officially protected—forests in the Philippines (Heaney and Regalado 1998). Since secondary tropical forests are less structurally complex (Brown and Lugo 1990), and may support a less diverse insect fauna than primary forests, the 22 species I recorded on Mount Makiling may only represent a subset of those species coexisting in primary forests. Unfortunately, there are no data available to make such comparisons. Ideally, since local mammal diversity varies with elevation (Heaney and Rickart 1990), and biogeographic region (Heaney 1987, 1993; Heaney and Rickart 1990), what is needed are comprehensive inventory/ ecological studies along elevation and disturbance gradients in each of the biogeographic regions in the Philippines. However in the short term, a more tangible goal would be a comparable study to that conducted on Makiling in primary lowland forest also on Luzon Island. Comparisons of species diversity and foraging behavior may offer insights into the disassembly of insectivorous bat communities, and the association between particular coexistence mechanisms, alteration of the environment, and species loss.

Acknowledgments

This work is in partial fulfillment of the requirements for a doctorate in Ecology and Evolution at the University of Illinois at Chicago. This research simply would not have been accomplished without the hard work and enthusiasm of my field assistant, Williardo Reyes. I am grateful to Arvin Diesmos, Danny Balete, and Philip Alviola for their assistance in the field. The manuscript benefited greatly from the comments I received from my advisors, Larry Heaney and Joel Brown. I am grateful to the staff of the Protected Areas and Wildlife bureau of the Department of Environment and Natural Resources, Manila; the University of the Philippines, Los Baños; and the Makiling Botanic Gardens for granting me permission to conduct research within the Makiling Forest Reserve. I received funding from Bat Conservation International, the Chicago *Zoological Society, the American Society of Mammologists, the Barbara Brown Fund (The Field Museum), and Sigma Xi.*

Table 1. Range (sample size) of external measurements of adult microchiropterans from Mount Makiling, Luzon, Philippines. Measurements in millimeters.

Species	Sex	Weight (g)	Forearm	Total length	Tail	Hind foot	Ear
Emballonura	M	4.8-5.3 (3)	46-48 (3)	62-68 (3)	11-15 (3)	6-9 (3)	10-16 (3)
alecto	F	6.8-7 (2)	46-49 (2)	68-71 (2)	15-22 (2)	8-9 (2)	14-15 (2)
Megaderma	M	15.5-16 (2)	57-60 (2)	72-74 (2)	-	17-18 (2)	36-38 (2)
spasma							
Hipposideros	M	4.1-6.5 (14)	38.6-40.5 (14)	70-75 (5)	26-28 (5)	6-7 (5)	16-18 (5)
ater	F	4.4-6.5 (16)	38.1-41.7 (16)	73-78 (2)	28-30 (2)	6-8 (2)	17-15 (2)
Hiposideros	M	35.5-48.5 (10)	79.6-83.7 (13)	140-145 (3)	41-48 (3)	16-20 (3)	25-31 (3)
diadema	F	33-40.5 (4)	77.9-81.7 (6)	129 (1)	43 (1)	15 (1)	30 (1)
Hipposideros	M	7.1-12 (4)	43.2-46(4)	72 (1)	19 (1)	11 (1)	20 (1)
obscurus	F	9-11.5 (3)	46.2-47.9 (3)	79-80 (2)	21-22 (2)	11-12 (2)	19-20 (2)
Hipposideros	M	5.2 (1)	43 (1)	76 (1)	28 (1)	8 (1)	17 (1)
sp.							
Rhinolophus	M	6.6-9 (3)	43.1-45 (3)	72 (1)	21 (1)	10 (1)	24 (1)
arcuatus	F	6.8-10 (7)	43.2-47.5 (20)	-	-	-	-
Rhinolophus	M	12.5-17 (5)	52.7-56.5 (5)	85-91 (4)	21-23 (4)	13-15 (4)	24-28 (4)
inops	F	11-18 (9)	52.6-56 (19)	84-93 (4)	20-24 (4)	12-14 (4)	26-27 (4)
Rhinolophus	M	5.4-7.5 (8)	43.1-46.1 (8)	75-82 (3)	25-29 (3)	8 (3)	25-26 (3)
macrotis	F	-	45.2 (1)	81 (1)	29 (1)	8 (1)	27 (1)
Rhiologphus	M	4.7-7.0 (9)	37.2-40.0 (9)	68-71 (5)	20-22 (5)	8-9 (5)	19-20 (5)
virgo	F	4.3-6.5 (18)	37.3-41 (24)	58-70 (6)	17-25 (6)	6-8 (6)	16-20 (6)

Table 1. (Continued)

Species	Sex	Weight (g)	Forearm	Total length	Tail	Hind foot	Ear
Kerivoula	M	3.5 (1)	30.7 (1)	79 (1)	37 (1)	5 (1)	16 (1)
*whiteheadii**							
Miniopterus	M	8.9-9.5 (3)	42.0-43.7 (3)	98 (1)	47 (1)	9 (1)	12 (1)
schreibersi	F	8.0-11.5 (5)	42.4-44.1 (5)	101-103 (3)	48-51 (3)	8-9(3)	12-13 (3)
Minlopterus	M	17 (1)	51.7 (1)	132 (1)	60 (1)	8 (1)	16 (1)
tristis	F	16 (1)	53.3 (1)	122 (1)	60 (1)	11 (1)	14 (1)
Murina	M	7.6 (1)	34.6 (1)	90 (1)	32 (1)	9 (1)	15 (1)
cyclotis							
Myotis	M	5.5-8.0 (33)	33.2-37.3 (34)	82.87 (3)	27-36 (3)	10-11 (3)	15-16 (3)
horsfieldii	F	6.0-10.5 (19)	34.3-38.2 (27)	83 (1)	34 (1)	10 (1)	15 (15)
Myotis	M	-	32.2 (1)	-	-	-	-
muricola	F	3.2-4.4 (2)	30.7-31.3 (2)	72-75 (2)	30-32 (2)	5-6 (2)	13-14 (2)
Philetor	M	13.5 (1)	38 (1)	110 (1)	35 (1)	10 (1)	16 (1)
brachypterus	F	13.5-14.0 (2)	33.4-35.9 (2)	91-99 (2)	32-34 (2)	9-10 (2)	14-15 (2)
Pipistrellus	M	4.5-7.0 (4)	30.9-32.6 (4)	77 (1)	31 (1)	6 (1)	10 (1)
sp. A	F	4.5-7.5 (5)	31.5-33.2 (6)	76-80 (3)	31-22 (3)	5-6 (3)	11-12 (3)
Pipistrellus	F	6.3-9.1 (5)	32.1-33.5 (7)	81-85 (6)	31-35 (6)	6 (6)	12-17 (6)
sp. B							
Scotophilus	M	24 (1)	50.3 (1)	-	-	-	-
kuhlii	F	15-21 (7)	47.7-51.5 (7)	117-124 (4)	43-48 (4)	11-13 (4)	15 (4)

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THE NIPAS LAW AND THE MANAGEMENT OF PROTECTED AREAS IN THE PHILIPPINES:
Some Observations and Critique

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ABSTRACT

The passage of the Republic Act 7586 otherwise known as NIPAS Act during the Fifth Regular Session of Congress on the 22nd of July 1991 represented a significant move towards the management of protected areas in the country. Its Implementing Rules and Regulations were issued as DENR Administrative Order No. 25 (DAO 25) on 29th June 1992.

At the heart of the Nipas Act is the Declaration of Policy which underscores, among other things, "the critical importance of protecting and maintaining the natural biological and physical diversities of the environment, notably on areas with unique features to sustain human life and development, as well as plant and animal life." In view of the magnitude of this task, no less than the powers of the State are invoked in order to secure for the present and future generations of Filipinos "the perpetual existence of all native plants and animals." To this end, a comprehensive system of integrated protected areas within the classification of national park as provided for by the Constitution has been established, and henceforth known as the National Integrated Protected Areas System or NIPAS.

Its grand objectives notwithstanding, the actual implementation of NIPAS Law remains fraught with controversy and, in many cases, both its substance and implementation continue to be mired in conflict. This paper critically reviews the salient points of NIPAS, examines some of the inherent weaknesses in its provisions, and analyzes the problem areas that impede the effective compliance of its requirements which, on the whole, undermine the very intent of its establishment. In turn, this paper offers important suggestions, foremost of which is the call for a major change in attitude within the ranks of the DENR staff and the

other program implementors. Specifically, this change of attitude involves no less than a call for DENR personnel "to cease being known as enforcers of regulations, but to consider themselves as development workers". Finally, in judging results, the paper underscores the need for implementors to go beyond the step-by-step compliance of requirements and to pay equally careful attention to the achievement of objectives, while highlighting the importance of a truly participative and consultative process of managing the natural resources of this country.

Introduction

Protected areas are defined by law as "identified portions of land and water set aside by reason of their unique physical and biological significance, managed to enhance biological diversity and protected against destructive human exploitation." The National Integrated Protected Areas System (NIPAS) is described as "the classification and administration of all designated protected areas to maintain essential ecological processes and life-support systems, to preserve genetic diversity, to ensure sustainable use of resources found therein and to maintain their natural conditions to the greatest extent possible."

It is stated in the Declaration of Policy of the NIPAS Act that "Cognizant of the profound impact of man's activities on all components of the natural environment particularly the effect of increasing population, resource exploitation and industrial advancement and recognizing the critical importance of protecting and maintaining the natural biological and physical diversities of the environment, notably on areas with unique features to sustain human life and development, as well as plant and animal life, it is hereby declared the policy of the State to secure for the Filipino people of present and future generations the perpetual existence of all native plants and animals through the establishment of a comprehensive system of integrated protected areas within the classification of national park as provided for in the Constitution." The Section further states that the use and enjoyment of the protected areas must be consistent with the principles of (conservation of) biological diversity and sustainable development.

Parks management issues prior to the passage of the NIPAS Act

The NIPAS Act is envisioned to offer a better alternative to the way protected areas or parks and equivalent reserves were being managed before 1992. Magno (1979) and Pollisco (1982) summarized the major issues in park management, pre-1992, in their papers, which were published in *Likas-Yaman*, Journal of the Natural Resources Management Forum. These issues include the lack of a clear cut definition and criteria for selection for the establishment of national parks; the need for better management of parks and equivalent reserves; lack of funds; inadequate manpower; presence of illegal settlers; inadequate protection; resource exploitation; and, the lack of clear park and equivalent reserves boundaries.

In response, Magno (1982) proposed a number of major recommendations which later provided much of the substance of the NIPAS.

1. National Parks and National Recreation Areas should be managed to preserve the natural environments for their continued use and enjoyment;
2. The administration of areas within the national parks system should be undertaken by a government agency advocating the single-use concept in national parklands. This agency should have powers to plan, develop, and regulate all activities within the areas, as well as the privilege to raise its own funds for operations and development projects.
3. The protection and development of national parks, national recreation areas, and equivalent reserves should proceed according to the following guidelines:
   a. A preliminary survey to determine the approximate boundaries of national parks should be undertaken before any plans for development may be initiated;
   b. A master plan based on resource base inventory must be prepared which will identify the location and extent of physical resources, designate land-use zones, detail specific protection needs, and make guidelines for the location and types of development appropriate for these areas;
   c. The actual development of national parks should be based on the priorities set in the master plan.
4. The development of national parks for tourism-recreation should be primarily oriented toward the enjoyment of the basic characteristics and properties that serve the intent and purposes of their establishment.
5. National parks development should be properly managed so that the character, purpose, and/or theme unique to each park and attractive to tourists may be preserved.
6. The system of national parks and wildlife areas should reassert its traditional role as preserver of the cultural and natural heritage of the Philippines.
7. Area boundaries must include entire ecosystems.
8. Ecosystem studies of the ecology of rare species should be conducted to provide the basis for better protection and biological data.
9. Environmental impact assessments should be conducted in all areas where developments are to occur.
10. Relocation of settlers to identified alienable and disposable lands should be undertaken immediately in areas where their numbers are still manageable.
11. For areas where relocation is no longer feasible and where almost one-half is intensively exploited by more than a

thousand households residing in the area for more than 25 years, a special arrangement or a compromise has to be reached between the occupants and the park management authority.

12. Buffer zones are to be established in the presence of industrial activities to minimize adverse effects on the areas' environment.
13. For purposes of protecting, maintaining and general management of the park, the administrative office should be adjacent to or within the perimeter of the parks.
14. Boundaries of national parks should be clearly defined and marked.

Salient features of the NIPAS Act and its Implementing Rules and Regulations

The Law requires that one year from its effectivity, the DENR shall submit to the Senate and the House of Representatives a map and legal description or natural boundaries of each protected area initially comprising the System. The Law also provides that within three years from the effectivity of the Act, the DENR shall review each area tentatively composing the System as to its suitability or non-suitability for preservation as protected area and inclusion in the System according to the established categories.

DENR Administrative Order No. 25, series of 1992 enumerates the series of steps that must to be undertaken in establishing the initial components of the System and they are as follows:

1. Compilation of maps and technical descriptions of protected areas
2. Initial screening to determine suitability or non-suitability of each area for inclusion under one or more of the existing categories as provided for in the NIPAS Act.
3. Public notification directed towards the local

stakeholders such as the LGU, the NGOs, POs, and IPs informing them of the presence of the protected area within their area, the result of the initial screening, the NIPAS Law and its Implementing Rules and Regulations, and other relevant matters.

4. Initial consultations for presentation of topics related to the implementation of the NIPAS Law as well as its goals and objectives
5. Census (Survey) and registration of protected area occupants of the proposed protected area and buffer zones. The activity should establish basic census data, the ethnographic and tenure status of migrants and indigenous communities, as well as provide a basis for establishing buffer zones and planning alternative livelihood activities.
6. Resource profiling or the collection and gathering of information on the biophysical features of the area including topography, unique geological features, soil type, existing vegetative cover, and flora and fauna, particularly threatened and endangered species, as well as important nesting or breeding sites.
7. Initial Protected Area Plan. This is a compilation of information developed in the studies and from other available sources. This should include a land-use plan for each protected area, which has been developed in coordination with the Regional Development Council. Indigenous people, tenured migrants, and others within the adjoining buffer zones and nearby communities should be involved as partners in this planning process.
8. Public hearings on the proposed inclusion of each area under the NIPAS.
9. Regional review and recommendation. This provides the opportunity for any modification of the boundary or management plan to be made. After all require-

ments have been met and support for inclusion of the area in the System has been given, the DENR Regional Office shall prepare the draft presidential proclamation for the area together with all the attachments and forward the same to the Office of the Secretary.

10. National review and recommendation. The Secretary, based on the review and recommendations of the Regional Offices, shall recommend to the President areas for inclusion within the System.
11. Presidential proclamation. This proclamation is issued by the President on the basis of the recommendation of the DENR Secretary designating the recommended area as a protected area and providing for protection measures until such time that Congress shall have enacted a law declaring the area as part of NIPAS.
12. Congressional action. For areas recommended by the DENR Secretary and have been proclaimed by the President, Congress shall enact a law establishing the areas as part of the NIPAS.
13. Demarcation. Upon the enactment of a law defining and establishing a protected area, the boundary of the said protected area shall be established and demarcated on the ground with concrete monuments or other prominent physical landmarks or features.

The NIPAS Law provides that the System shall be placed under the control and administration of the DENR creating a Protected Areas and Wildlife Division in each Regional Office. This division will be under the supervision of a Regional Technical Director and shall include subordinate officers, clerks, and employees as may be proposed by the Secretary, duly approved by the Department of Budget and Management, and appropriated for by Congress. The Law further provides that "the service thus created shall manage protected areas and promote the permanent preservation, to

the greatest extent possible of their natural conditions."

Each protected area shall have a Protected Area Management Board, which will decide the allocations for budget, approve proposals for funding, decide matters related to planning, peripheral protection, and general administration of the area in accordance with the general management planning strategy. It shall be composed of the DENR Regional Executive Director under whose jurisdiction the protected area is located, one representative from the autonomous regional government, if applicable; the Provincial Development Officer; one representative from the municipal government; one representative from each barangay covering the protected area; one representative from each tribal community, if applicable; and at least three representatives from non-government organizations and, if necessary, one representative from other departments or national government agencies involved in protected area management

The Law calls for the drafting of a **general management planning strategy to serve as a guide in formulating individual plans for each protected area** (*emphasis added*). The management planning strategy shall promote the adoption and implementation for innovative management techniques including the concept of zoning, buffer zone management for multiple use and protection, habitat conservation and rehabilitation, diversity management, community organizing, socio-economic and scientific researches, site-specific policy development, pest management, and fire control. It shall also provide guidelines for the protection of indigenous peoples, other tenured migrant communities and sites, and for close coordination between and among local agencies of the Government, as well as the private sector. **It also provides that each protected area shall have a management plan prepared by three (3) experts** (*emphasis added*).

Proposals for activities that are outside the scope of the protected area's management plan shall be subject to an environment impact assessment. No actual implementation of such activities may be allowed without the required Environmental Compliance Certificate.

A trust fund known as the Integrated Protected Areas Fund (IPAF) has also been established for purposes of financing the projects of the System.

STATUS OF COMPLIANCE WITH THE PROVISIONS OF THE NIPAS LAW

Attached is a matrix showing the status of accomplishments related to the establishment and management of protected areas under the NIPAS (Table 1 and Table 2). It should be noted that there are separate matrices for the initial and additional or proposed components of the System. The matrices have the following as headings: REG or the Philippine administrative regions; NO. of IC or the number of initial components; COMP. OF MAPS or the number of maps which have been prepared; PH/PC or the public hearing or public consultation which have been conducted; PASA or the Protected Area Suitability Assessment (another name for Initial Screening) which have been conducted; CRPAO or the Census (Survey) and registration of protected area occupants completed; RBI or Resource Basic Inventory (Resource Profiling) conducted; IPAP or the Initial Protected Area Plan drafted; PAMB or the Protected Area Management Board organized; DRAFT PROC or the draft proclamations prepared; NEWLY PROC or the newly proclaimed protected areas; and PA BILL or protected areas bills which have been enacted by Congress into law.

As of February 28, 2001, the matrices showed 209 initial components (Table 1) and a maximum of 143 additional or proposed protected areas for inclusion (Table 2) in the System. This analysis of compliance to the NIPAS Law will focus on the more critical phases of the establishment of the System and these are the Initial Screening or the Protected

Area Suitability Assessment, the Census (survey) and Registration of Protected Area Occupants, Resource Profiling or the RBI, the IPAP and the PAMB.

The PASA (Protected Area Suitability Assessment)

The figures in the matrices show that PASA has been conducted in a large majority of the initial components (180/209) and in all proposed or additional components of the System (143/143). The statistics might be good, however, the quality of the information should also be examined. It should be recalled that the PASA determines the suitability or non-suitability of an area for inclusion in the System. If an area is found suitable, the PASA also indirectly determines the category of protected area under which an area may be included.

DENR Memorandum Circular 17 series of 1992 sets the guidelines for the conduct of the PASA. The document says that the conduct of the PASA involves three activities: (1) secondary data collection; (2) on-site observation; and, (3) interviews. The guidelines, however, contain a number of problem areas. For instance, PASA Form No. 1 is meant for on-site observations and has three sections – general information, natural features, and cultural features. Although there is an attempt to quantify the data collected from on-site observations, no clear-cut methodologies have been recommended so that data collected can be quantified and objectively reported. Likewise, the section on cultural features would require an observer with an expertise in anthropology. For example, the guide question on cultural features asks the observer to indicate the various cultural practices, beliefs, and traditions of people in connection with the use of natural resources. The answer to this particular guide question can perhaps be obtained from a secondary source. Yet, as everyone knows, culture and practices of people change over time such that what could have been true a few years back may no longer be true at the time that the PASA is being conducted.

PASA Form No. 2 is the interview questionnaire. It also has three sections—natural features, cultural features, and current programs/projects/activities. The section on natural features appears to be a repetition of the same section in Form 1, except that in this form, the information will be obtained through interview. If the same information may be obtained through on-site (meaning first hand) observation, getting the same information through an informant becomes a needless exercise. Similarly, the sub-section on flora and fauna calls for an enumeration of dominant and economically important plant species, the species of fauna, as well as nesting and breeding sites found in the area. Since the form simply requires no more than a simple listing of fauna or flora found in the area, answers such as cat, dog, carabao, goat, or horse are therefore not at all uncommon. Detailed instructions on how the questionnaire should be filled and distributed are lacking. Consequently, data are not systematically, scientifically, and quantitatively collected, leading to subjectivity in the resulting information.

Unfortunately, subjective as they may be, the inputs in Forms 1 and 2 are expected to be the basis for filling out Form No. 3, the final rating sheet in determining suitability or non-suitability of an area for inclusion in the System. The criteria used in the rating sheet include "representativeness" or whether habitat types are **representative** of the biogeographic zone of the area; 'naturalness" or **percentage** of the area which is still intact; "abundance" or presence and number of individual per species of flora and fauna in the site (not only has the criterion become suddenly quantitative, but in this instance, it has gone to the other extreme by asking for the **number of individuals per species** of flora and fauna in the area!); and, "diversity" or the presence and number of flora, fauna in the site (*emphasis added*).

The results of all PASA activities which faithfully followed Forms 1 and 2 need to be closely scrutinized since

subjective and unquantified data are used for a rating system which needs quantified data.

The CRPAO (Census and Registration of Protected Area Occupants)

The CRPAO or the SRPAO (Survey and Registration of Protected Area Occupants) is the basis for establishing management zones and buffer zones and for the preparation of management programs including the identification of alternative livelihood opportunities. The CRPAO (or the SRPAO) is also the basis for determining who would be awarded the tenurial instrument for protected areas.

The objectives of the SRPAO are exacting: (1) to determine and attest to the **actual number** of occupants within the protected area; (2) to **establish the exact location** and approximate size of the home lots/farm lots of protected area occupants; (3) to check and **confirm the period of occupancy** over certain portions of the protected area; and, (4) to document/register the actual number of protected area occupants and households and the extent of area occupied during the census (emphasis added). It is clear from the objectives of the exercise that the intent is a 100% survey of protected area occupants. It appears in the summary report of accomplishments that the exercise has been completed in 123 out of 209 initial components and 73 out of 143 additional or proposed components of the System. The figures, however, are misleading since except for protected areas with no occupants, **no SRPAO has been 100% accomplished** (*emphasis added*). Without the SRPAO there will be no basis for awarding tenurial instruments for protected areas. The SRPAO should not be done piecemeal because awarding of tenurial instruments and other benefits should not also be piecemeal. Any deviation from the desired timetable will create distrust and destroy goodwill. Alternative livelihood opportunities are supposed to be one of the benefits accruing to settlers who qualify for tenure. Without a complete SRPAO livelihood programs will be difficult to implement. It appears that one reason why the livelihood funds for the GEF-World Bank-supported Conservation of Priority Protected Areas Project are largely unspent is because of the failure of the project proponent to recognize that the survey of protected area occupants is a pre-requisite to the establishment of livelihood programs in PAs and that funds should be allocated for the exercise.

The RBI (Resource Basic Inventory) or Resource Profiling

DENR Memorandum Order No. 10, series of 1991 sets the guidelines for the conduct of Resource Basic Inventory (RBI) within protected areas. RBI is described as the collection, analysis, and synthesis of relevant information on the ecological, geological, physical, social, economic, and historic environment of a particular protected area. Its purpose it to provide comprehensive compilation of data for the development, management, use, and interpretation of protected areas. It shall also serve as a **pre-requisite for the preparation of a master plan** for a particular protected area (*emphasis added*).

A manual for the implementation of MO 10 was later released. On evaluation, the RBI manual showed bias towards flora and fauna assessment and **did not satisfactorily comply with the requirement that it should cover the ecological, geological, physical, social, economic, and historic environment of a particular protected area** (*emphasis added*). The sampling techniques for flora and fauna leave room for improvement. For example, the sampling intensity and how the sample plot, or transects, or collection areas can be distributed in the area being assessed were not indicated in the manual. The instructions for the Point-Center Quarter Method should also be reviewed since the instruction say that it should be used to sample understorey trees of less than 2 cm and overstorey trees of 20 cm dBH or bigger (emphasis

added). The terrestrial fauna assessment techniques did not indicate which methodology would be best for each group of vertebrate fauna, such as birds, mammals (volant and non-volant), reptiles, and amphibians.

The scanty information coming from the RBI will have serious consequences on the reliability of information that will form the basis for the preparation of the master (management) plan. Consequently, the need to generate more reliable data to be used in drafting the plan cannot be overemphasized. Results of investigations done by both local and foreign researchers on protected areas like Mt. Kitanglad, Mt. Apo, Mt. Guiting-Guiting, Northern Sierra Madre, Mt. Pulag, and Mt.Isarog, are potential sources of vital information, except that most if not all of these researches are products of independent efforts rather than carried out as part of the RBI.

The IPAP (Initial Protected Area Plan)

As indicated earlier and as provided for by DENR Administrative Order 25 series of 1992, the IPAP shall include the basic rationale for the protected area; the proposed boundaries including buffer zones; and, an initial designation of management zones, including buffer zones, with purposes, strategies, and allowable uses specified for each. There is an additional reminder that indigenous peoples (or cultural communities), tenured migrants within the proposed protected area, and nearby communities should be involved in the planning process.

All the initial studies and activities, such as the PASA, the CRPAO (SRPAO), the RBI are pre-requisites for the preparation of this plan. However, the pre-requisites have not been complied with satisfactorily. Without reliable information from the PASA and the RBI, the basis for the designation of management zones is open to questions. Where are the critical habitats, what is their extent and coverage, what species would be the focus of conservation and management programs, what is the distribution of these species within the area? Are only some of the questions that may arise. Without the complete survey of protected area occupants, more questions such as where the communities are concentrated, or what management programs will be implemented for them and with them, will continue to be asked.

The lack of information is further complicated by the fact that most of the IPAP were desk jobs and it is doubtful whether IPs and the communities were ever involved in the planning process. Tenured migrants definitely could not have been involved since there is no CRPAO which has been satisfactorily completed in areas with settlers and **the policy for the granting of tenure to qualified protected area occupants has not been issued, yet** (*emphasis added*).

The European Union-funded National Integrated Protected Areas Programme (NIPAP) has somehow overcome the lack of information through the 3D modeling exercise it conducted in the protected areas included in their Programme. The 3D model is a three-dimensional scale model of a protected area where the features such as vegetation type and coverage, location of bodies of water, roads and trails, settlements, land-uses, and other unique properties of the area are provided by key informants from the area itself.

The PAMB (Protected Area Management Board)

The summary of NIPAS accomplishments indicates that 91 out of the 209 initial components and 18 out of the 32 newly proclaimed additional areas of the System have Protected Area Management Boards or PAMBs.

Since DAO 25 has set the frequency of **PAMB meetings at once a month** (*emphasis added*), the DENR Regional Offices have been experiencing enormous problems in the organization and in the scheduling of PAMB meetings. There are many regions where the number of protected areas approach 30 and, there are some cases where the number is even

bigger. As the designated Chair of the PAMB, the DENR Regional Executive Director (RED) is expected to be present at PAMB meetings. But given the number of PAs in the region, this would require the RED to attend a PAMB meeting everyday, including Saturdays, Sundays, and holidays, in various areas which are oftentimes in considerable distance from each other. This would not only be a tall order for any official, it is downright physically impossible to happen. Although the authority to chair meetings can be delegated, the importance of the RED's presence in such meetings is widely considered significant.

There is also the financial side of the problem in holding PAMB meetings. There is a need to provide for the transportation expenses and allowances, as well as the food and accommodations especially of members from the low-income groups during the meeting itself. The DENR budget does not provide funds specifically for each protected area for PAMB operations. The decision to provide such funds rests solely on the discretion of the RED. In some areas, however, the involvement of LGUs and other organizations in assuming the financial responsibility has solved the problem of hosting PAMB meetings.

Attendance has also become a problem because of the waning interest of some members in attending such meetings due to lack of incentives such as allowances and reimbursement for travelling expenses. Another reason a reason for non-attendance in meetings is the conflict between the management objectives of a particular protected area and the economic interests of some members, especially as regards extraction or utilization of resources such as wood, minerals, or land. At the other end of the scale are those members who insist on remaining in the Board long past their term of office as PAMB member. This problem stems from the fact that the tenure of PAMB members is five (5) years while the term of office of LGU officials is three (3) years. It can happen, therefore, that there would be PAMB members who do not technically represent their local government.

The members of the PAMB come from different sectors. Some are not aware of what is expected of them and are not familiar with way the duties and responsibilities of board members are discharged. Hence, capability building for members so that they can become effective in the Board and in protected area management is of vital importance.

The Protected Area Superintendent (PASu) and Staff

Ideally, with the passage of the NIPAS Act, positions or items for the PASu and staff should have been created and funded by the government. This, however, has not materialized in the past ten years since the National Government embarked on a program of streamlining the bureaucracy. Except for some of the PAs under the foreign-assisted projects, most of the PASu and staff are only on detail to the PA from some other DENR units. The continuity of their service to the PA, therefore, is dependent on the need for their services in their respective mother units.

It has also been suggested that forest rangers from the forestry sector be assigned to protected areas to assist the PA staff. This has not materialized because, first, the proposal has not been officially submitted and, second, because it is unclear whether the persons holding the items would still have the physical ability or stamina to patrol the protected areas.

Boundary Delineation and Demarcation

No protected area boundary as of now has been demarcated on the ground simply because of the expense involved and no entity, whether foreign-assisted project or government-run, has planned and allocated funds for this activity. It has been estimated that PhP15, 000 to PhP17, 000 would be needed for every kilometer of protected area boundary demarcated. The figure for the demarcation of some 200 protected areas comes to about PhP2.6B. It will take a miracle

for the government to appropriate this amount for protected area management.

The Integrated Protected Area Fund (IPAF)

The IPAF is the trust fund created or established for the purpose of promoting the sustained financing of the System. The Fund includes taxes, donations, endowments, and grants, fees and fines, and all income/revenues generated from the operation of the System. Seventy-five percent of the income derived from the operation of a particular protected area accrues to the sub-fund created for the protected area and 25% goes to a general fund called the Central IPAF. The sub-fund for the protected area can only be disbursed for the protection, maintenance, administration, and management of the PA concerned.

The 01 February 2001 summary report on income generated by protected areas shows that only 51 protected areas generated some income for a total of PhP50M from the beginning. The biggest contribution to the IPAF came from the Ninoy Aquino Park and Wildlife Nature Center, which was able to generate PhP37.4M. The balance of this fund is only PhP9M. The next biggest grosser is Hinulugang Taktak National Park with total income generated at PhP6.2M over the same period. One marine protected area that has been realizing income is the Apo Island Protected Landscape and Seascape. For 1990, more than a million pesos have been collected. In this case, the share of the Park was partly released only after nearly a year.

The IPAF will not be able to sustain the maintenance of the System at current rate of income generation and the present number of protected areas that can generate income.

Management Plan

The Law prescribes that three (3) experts prepare the individual management plan for the protected areas.

Present realities, however, dictate that management plan preparation should be participatory and consultative. There have been in fact two occasions when the plan preparation was done in a participative and consultative manner and yet the final output was still questioned because a stakeholder group was not involved in the planning process. Except for Olango Island Wildlife Sanctuary, Tubbataha Reef National Park, Naujan Lake National Park, only the GEF-World Bank or the European Union-supported PA projects have draft management plans.

No management plan has yet been approved in the prescribed process and so whether the plans will be realized or not remains to be seen. It is expected that the EU-NIPAP drafted management plans will have fewer problems in implementation since they were drafted in a truly participatory manner. The different stakeholders through workshops had a direct participation in the drafting of the management plans. NIPAP also had the 3D models of the PAs which serve as reliable sources of information and convenient management tools.

The GEF-World Bank that supported the CPPAP project employed the services of a team to draft the management plans for their PAs. These plans would most probably already have the endorsement of the PAMB and will be approved by the Secretary, but as experience has shown, there will be more problems in their implementation because of the manner the plans have been drafted.

Where do we go from here?

A common practice at DENR is to judge performance according to whether a certain task or tasks have been completed. This manner of judging performance privileges the compliance of instructions over the achievement of de-

sired results or the attainment of objectives. It is usually enough that personnel comply with an instruction or that we have satisfied a key result area (KRA) regardless of whether the desired results have been achieved in the performance of the task. A good example of this kind of attitude is the way people comply with the step-by-step requirements that need to be taken in establishing protected areas within the System. Although a majority has reported compliance with the PASA and the RBI requirements, documents show that the objectives of these two exercises have not been met satisfactorily. Were the people who conducted these exercises aware of the desired output? In fact, were these exercises conducted at all? This last question is asked because if they were done, questions should have been raised.

The CRPAO is another example of the effect of this attitude. The conduct of the exercise has been given full credit even if only 1/100 of the task has been done. There has been no reaction from the implementors of this exercise no matter how much it has been stressed that only a 100% conduct of the CRPAO is acceptable and that it will be the basis for granting of tenurial instruments to qualified migrants. In the absence of a valid survey and registration of all protected area occupants, chaos will surely ensue in the granting of this tenurial instrument.

The rate of population increase in the Philippines does not show any sign of slowing down. There will be more people and less land to till. The migration of landless people to government lands including terrestrial protected areas will not end. It was envisioned in the DENR support policies that the organized communities receiving the tenurial instrument would at least be able to help stem the tide of migration into protected areas, but without the CRPAO there will be no organized communities to help in PA management.

The issue of organized communities brings up the need for DENR personnel especially in the Protected Areas and

Wildlife Service to undergo a major change in attitude and become effective community organizers. We have to bring to reality what past DENR Secretaries have often stressed that we have to cease being known as enforcers of regulations but rather as development workers. We have to stop the practice of registering peoples' organizations with the SEC and announcing that such groups are already organized. People have to be really organized and being organized means that they are empowered. Empowerment means that organizations can plan, implement, and monitor their own plans and programs. It also means that people can make their own decisions.

The idea of having a PAMB is for the communities and the stakeholders to help in PA management. The organization of a PAMB is a way of devolving the protected area management functions of the DENR to the PA stakeholders. Having representatives of organized and responsible groups or communities in the PAMB will certainly mean an active PAMB. The PAMB as a body, however, would also need some organizing and capability building for it to be fully functional.

The planning for protected areas, such as the preparation of the Individual Protected Area Plan (IPAP) should be strictly participatory and consultative if the intent is for the Plan to be implemented with the participation of stakeholders. Unless the stakeholders feel they own the Plan it would be difficult to implement at all.

The more technical requirements of the PASA and the RBI will be easier to solve. The Wildlife Conservation Society of the Philippines can perhaps play a crucial role in improving the methodologies used in the conduct of the above-mentioned activities. What would be needed is to put together a multi-disciplinary group of practicing experts in flora, fauna, geology, limnology, marine science, social science, anthropology, and other relevant fields to sit down, review, and improve on what is currently available.

As a trust fund for ensuring the sustained financing of the System, the IPAF and its potential for generating income for PAs should be taken advantage of by PA managers. With the help of policy makers in the Central Office, PA managers will have to be more imaginative and/or active in thinking of ways to generate funds for the PAs. User fees for water is one potential source of funds. Proper consultations with all affected parties should, however, be done to avoid misunderstandings. The government should invest more in protected areas to make them more attractive to tourists, both local and foreign. Any development, however, should be directed towards preserving and highlighting the natural features of protected areas. The development for tourism in protected areas should be in the form of facilities to help visitors enjoy nature. Development should do away with swimming pools, tennis courts, or basketball courts. More visitors to protected areas would mean a greater prospect for income from fees. However, fees for use of facilities should be within the reach of majority of the people.

A short review of the past issues in protected area management and their relevance to the present is given in Table 3.

Conclusion

We, at the DENR, have not been able to satisfactorily comply with the timetable of activities and the substantive intent for the establishment of the System as provided for by Law. It might be that the framers of the Law were too optimistic and took for granted the availability of resources at our disposal. It might also be because we are setting foot on unfamiliar grounds. There is a need to examine what has happened in the implementation of the Law, to dissect the critical activities, and to discover the flaws that need to be corrected. Nobody is perfect, there is always room for improvement. We will further lag behind in protected area management and miss all opportunities to conserve our natural heritage, if we do not make the needed corrections now.

To our colleagues in the DENR and in PAWB in particular, we would like to state that this paper does not look at people but rather at activities. The senior author shares the responsibility for whatever shortcomings there are in the interpretation and implementation of the NIPAS Law.

Table 1. Summary of NIPAS accomplishments: Initial Components as of February 28, 2001.

Region	No. of IC	COMP. OF MAPS	PH/PC	PASA	CRPAO	RBI	IPAP	PAMB	DRAFT PRO
CAR	9	9	7	8	8	7	7	7	5
1	16	16	14	14	11	14	14	7	14
2	1'0	9	9	9	7	9	8	5	9
3	15	17	12	15	14	12	12	7	10
4-A	34	27	25	26	16	17	16	8	24
4-B	15	11	9	8	9	9	7	5	6
NCR	1	1	1	1	0	0	0	0	1
5	23	13	18	19	9	16	16	112	15
6	12	12	12	11	7	8	8	3	12
7	18	13	27	28	11	13	25	16	27
8	9	9	11	10	8	7	6	7	6
9	7	7	6	6	6	6	6	6	6
10	8	7	8	8	6	6	6	6	8
11	9	9	8	8	6	4	8	1	8
12	3	3	3	3	1	3	3	0	3
13	10	7	5	5	3	4	5	1	5
ARMM	10	3	1	1	1	1	0	0	0
TOTAL	209	173	176	180	123	136	147	91	159

Table 2. Summary of NIPAS accomplishment: Additional/Proposed Areas as of February 28, 2001

Region	COMP. OF MAPS	PH/PC	PASA	CRPAO	RBI	IPAP	PAMB	DRAFT PROC	NEWLY PROC	PA BILL
CAR	0	7	6	0	6	8	0	7	0	0
1	0	4	5	1	5	5	0	5	0	0
2	1	5	6	1	4	4	2	3	2	0
3	1	4	5	3	5	4	1	4	1	0
4-A	1	2	9	1	3	2	1	4	1	0
4-B	1	13	13	5	6	6	3	11	4	0
NCR	0	0	0	0	0	0	0	0	0	0
5	0	1	4	4	4	2	0	1	0	0
6	2	2	3	4	2	4	1	4	1	0
7	2	17	23	10	11	13	3	12	3	0
8	2	24	30	21	30	31	5	23	6	0
9	1	7	7	6	6	8	0	12	7	0
10	1	13	14	9	11	13	0	9	1	1
11	0	4	6	3	5	5	0	5	3	0
12	1	6	3	3	3	3	1	4	2	0
13	1	6	9	2	7	6	1	4	1	0
ARMM	0	0	0	0	0	0	0	1	0	0
TOTAL	14	115	143	73	108	114	18	109	32	1

Table 3. A short review of the past issues in protected area management and their relevance to the present.

Before NIPAS Law	Under NIPAS Law
1. Lack of clear cut definition and criteria for the establishment of national parks	1. The present criteria for categorizing protected areas are still not clearly defined with the consequence that more PAs fall under the category of "Protected Landscape"
2. The need for better management of parks and equivalent reserves	2. The foundation for better management of protected areas has been set. Instead of a centralized management of protected areas, we now have a decentralized system with the PAMB
3.Lack of funds	3. This is still a problem for major activities. Minor activities can be funded through the IPAF or through the creativity and resourcefulness of PA management
4.Inadequate manpower	4. Still a big problem. This can be partially solved if local manpower resources through organized groups and the PAMB can be tapped. The local stakeholders can be tapped for enforcement of regulations, for protection, as well as for community organizing and development activities.
5. Presence of illegal settlers	5. It is still an issue but if the SRPAO will be properly carried out, communities are organized, and tenurial instruments awarded, this concern can be minimized
6. Inadequate protection	6. Can be addressed with the help of local stakeholders
7. Resource exploitation	7. The NIPAS Law is clear on resource exploitation within Pas; besides the local stakeholders can help in the enforcement of regulations if they are organized.
8. Lack of clear-cut boundaries	8. Still a big problem because of the cost involved. Innovative solutions need to be sought.

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NOTES

THE CENTROP EXPERIENCE: PAST, PRESENT, & FUTURE

ANGELITA M. CADELIÑA AND MIRASOL N. MAGBANUA

Introduction

A political scientist from Yale University has aptly said that both theory and common sense should let us know that infinite material and population growth on a finite planet is impossible. Thus, the greatest challenge a developing country faces is transforming its citizenry from being complacent, consumer goods-oriented individuals to being caring and protective constituents. Environmentalists have attributed the economic situation of the Philippines today to the country's non-protective stance of its environmental assets, such as the watershed, forest, and wildlife. To strike a balance between economic development and environmental protection is every country's legitimate concern. Yet, in the name of "economic development" (based on the principle of food security), political leaders have compromised the ecological integrity of this country. Therefore, the only recourse to avert the complete deterioration of wildlife habitat is proper management of this habitat by people themselves. This has always been the guiding principle behind all the programs and activities of the Center for Tropical Conservation Studies (SU Centrop) at Silliman University. Specifically, Centrop's programs and projects revolve around community-based biodiversity conservation, wildlife conservation, breeding and management, environmental awareness, and advocacy campaigns.

Laying down the Scientific Groundwork: The First Six Years (1991 - 1997)

Silliman University Center for Tropical Conservation Studies (SU Centrop) was started in 1989 to promote the conservation of natural terrestrial habitats and endemic wildlife through research and community-based biodiversity conservation programs. It was given official recognition as a research and community outreach unit by the Silliman University administration in 1991. Initiated by a group of faculty members of the Silliman University Biology Department, the program was originally envisioned as a center for terrestrial wildlife conservation. Its initial contacts with the IUCN Deer Conservation Specialist Group led to its establishment in 1990 as the first local, *in situ* breeding center for the conservation of the Philippine Spotted Deer. The conservation breeding programs also expanded to include the Visayan Warty Pig, the Leopard Cat, and Philippine Fruit Bats. The breeding center facility of Centrop, which was established in 1994 as a small zoo, is now officially opened to the public as the A. Y. Reyes Zoological and Botanical Garden. This greatly enhanced the conservation campaign of Centrop and major support was sought to develop the breeding center, the mini-zoo, and the interpretive center. Implementation of this plan started in a small way through the interaction of Centrop staff and visitors.

With support from the Haribon Foundation and later from the Foundation for Philippine Environment, Centrop's activities expanded to include a conservation education awareness campaign among rural upland areas in Negros Oriental. Started in 1995 the conservation campaign among rural communities has now evolved into a more intensive community capability building program focused on the conservation of the remaining forests and wildlife and the sustainable utilization of natural resources.

Studies conducted by Centrop-based researchers found their way into such journals as the *Asian International Journal of Life Sciences, Journal of Tropical Ecology, Sylvatrop* and Silliman University's own official publication, *Silliman Journal*.[1] Most of the researches were on the subject of mammal conservation (bats, spotted deer, wild pig). The strong commitment of both the international and local scientists to help in saving said animals from imminent extinction finds expression in the publication of these researches.

In addition, some faculty members of the Biology department have participated in museum and wildlife management training held either locally or abroad.

CENTROP'S Mission, Vision, and Goals

The environmental situation of the Philippines has been considered as "the single worst case scenario ... of biological diversity in tropical Southeast Asia." La Viña, et al. (1997) have lamented the fact that although the Philippines is biologically rich, it has "experienced a veritable biological meltdown over the past decades, losing most of its dipterocarp forests, mangroves, and coral reefs, and experiencing extinction rates unparalleled in South-East Asia, and perhaps anywhere in the world."

Cognizant of this deplorable situation, Centrop formulated its vision, mission and objectives, reflecting in them the aspirations of upland terrestrial communities where the resource base is forestry and agriculture. These vision, mission and objectives constitute the guiding philosophy of the Mt. Talinis-Twin Lakes Area Management Framework Plan. Through this Management Framework Plan, Centrop envisions nature terrestrial habitats that are capable of providing adequate life support needs of the community. In consonance with this vision is the program's mission to become an effective agent in disseminating better understanding of natural ecosystems and their biodiversity so that their life support functions will be enhanced and preserved even for the coming generations.

In seeking to carry out this mission, the Center sees its objectives as conducting research on terrestrial ecosystems, especially on forest and wildlife; promoting wildlife conservation and management practices based on scientific principles and research; promoting the active involvement of communities in wildlife conservation programs; conducting community capability building programs in upland and rural areas for sustainable resources utilization, especially sustainable farming; soliciting community support for conservation through environmental awareness and education campaign programs; establishing linkages with various academic and governmental institutions, NGOs, and other organizations concerned with resource utilization for collaboration and exchange of information; and, seeking support and assistance towards the development of institutional self-sufficiency.

Research and Community Extension Programs

Through the years, Centrop's research and community programs have acquired a number of unique features. One unique feature is its use of an interdisciplinary approach which involves a shift from purely natural science emphasis to the use of scientific knowledge in community extension work, thereby utilizing social science processes. For instance, knowledge (gained through attendance in training, seminars, and workshops) on how endangered fruit bats, deer and wildpigs can be protected is passed on to cooperating communities through interactions of Centrop staff with communities at workshops and seminars, and hands-on activities both at the site and at the Centrop

deer information facilities.

Another unique feature is the involvement of other agencies, such as the Peace Corps Volunteer (PCV), Non-government Organizations (NGOs), Government Organizations (GOs), and Local Government Units (LGUs) in collaborative efforts on biodiversity conservation, sustainable agriculture, livelihood generating projects, watershed management, and environmental protection advocacy through legal means (ordinance, resolutions).

In addition, Centrop carries its environmental protection work on to elementary and secondary schools, as well as out-of-school youth through its school and youth camp activities. Lately (2001) the interpretive facilities at Centrop's A.Y. Reyes Zoological and Botanical Garden have become the vehicle through which concepts of conservation breeding and endangered animal protection are explained to visitors during the guided tour and in the discussions that follow.

Moreover, published and unpublished materials on mammal conservation, endangered animal conservation breeding, feeding, and interfacility animal exchange and others, both in the name of Centrop or by Centrop's previous and current staff, have enhanced the scientific thrusts of the center.

Finally, as part of its conservation campaign among rural communities, Centrop has expanded its role in community capability building initiatives by training people to become watershed and habitat managers, ecosystem monitors, wildlife protectors, and productive farmers. Enabling rural people to manage their own resources (an idea which has gained nationwide acceptance) is one of Centrop's most challenging tasks.

Research Programs

The pioneers of Centrop were very much interested in the study not only of wildlife biology and the conservation benefits derived from wildlife, but most importantly of the way upland communities might be able to share the benefits derived from proper management of wildlife. The research thrusts of the Center therefore have revolved around the issues of biodiversity loss due to wildlife habitat disturbance. The issues of threatened habitats to which loss of biodiversity is attributed are markedly reflected in the subject of researches done in the name of Centrop or by their authors during and after their stint at Centrop. More importantly the research findings that are validated in cooperating communities are Centrop-initiated activities, which involve wildlife monitoring and management.

As a conservation facility for the Philippine Spotted Deer captive breeding program and the Interpretive Center of the A. Y. Reyes Zoological and Botanical Garden, Centrop attracts researchers within and without Silliman University who make the captive-bred animals as subjects of their studies. For instance, a majority of these researches by senior researchers in collaboration with Centrop staff are on the subject of vertebrate biodiversity. The results of these researches have been either published in local and international journals or presented in a number of symposia. Some of these have also found creative expression in advocacy posters, such as those about endemic vertebrates, jointly prepared by SU Biology-Centrop and other government agencies.

Some of the data collected by Centrop staff constitute the background information for researches on habitat utilization of the Philippine Spotted Deer in Calinawan, west of Mt. Talinis; on associated flora and fauna of the habitat of the Philippine Spotted Deer in Calinawan, west of Mt. Talinis; on the status of biodiversity of Ayungon Forest; on the Fruit Bats of Mantikil, Siaton and Calinawan, Enrique Villanueva, Sibulan, Negros Oriental; studies on the Greater Bamboo Bat *Tylonycteris robustula* in Mantikil, Siaton, Negros Oriental; as well as observations on distribution of Fruit Bats in the Island of Negros.

SUPPORT SYSTEM

Foundation for the Philippine Environment (FPE) - 1992 to date

Empowering the rural areas for biodiversity conservation and management has always been the guiding principle of the Foundation for the Philippine Environment (FPE) in extending a project grant to Centrop since 1992. This grant constitutes FPE's public recognition of Centrop's own work on biodiversity conservation management in the rural areas.

To date the major output from the FPE-support grant is the "Mt. Talinis-Twin Lakes Area Management Framework Plan". The Plan reflects the collective aspiration and goal of the watershed dwellers of the area, which is the improvement of the quality of their life without compromising the ecological integrity of their place of abode. With the technical assistance from Centrop and support from Foundation of the Philippine Environment (FPE), watershed dwellers hope to realize their goals and aspirations during the implementation phase in 2001. In this collaboration, Centrop has found a partner in FPE to take on the challenge of the Center's objectives, which are to enable the watershed dwellers in mobilizing community resources to uphold the integrity of their forest ecosystem without jeopardizing their livelihood; advocate a change in attitude and behavior in the task of conserving biodiversity through wildlife conservation activities; and encourage as well as enable cooperating farmers in improving their farm productivity through activities based on sustainable agriculture. For their part, community members organized themselves into a People's Organization in order to realize these objectives with the help of the Centrop field staff and local leaders. Their efforts resulted in a number of initiatives foremost of which are agroforestry development which involves organic farming, integrated pest management, and forest and forest tree planting in homes and communal lots; the establishment of plant nurseries which were maintained until all designated out planting areas were saturated; the establishment of an arboretum for the propagation of indigenous species; and the protection and monitoring of forest and wildlife.

Specifically, activities in forest and wildlife protection and monitoring include tree planting, identification, and marking of mother trees in the Mt. Talinis development area, inventory and monitoring of forest resources in Barangay Lunga and Magsaysay; inventory of flora and fauna by scientific and community-based approaches; study of Philippine spotted deer habitat; training of forest guides for the Mt. Talinis area; soliciting participation of approximately 100 Deputized Environmental Natural Resources Officers (DENROs); formulation of community Resource Management (CRM) development plans by 16 barangays; encouragement of 8 POs to apply as Community-based Forest Management Agencies (CBFMAs); and the declaration of a 370-hectare primary forest area in Barangay Enrique Villanueva as wildlife sanctuary through passage of resolutions by PO and barangay.

Flora and Fauna International, 1992 to date[2]

Since 1992 to date, Flora and Fauna International (FFI) has been supporting the Philippine Spotted Deer and Visayan Warty Pig Conservation Program at SU Centrop. The Philippine Spotted Deer is listed in the *Critically Endangered Species Category* (IUCN 1996) while the Visayan Warty Pig is the most threatened species of native pig in the world (Oliver 1997). Centrop is a member of an international network of organizations working for the conservation of these species.

As earlier mentioned, the breeding center at Silliman is the first local *in situ* breeding center.

SU-USAID-COE-CRM Marine Laboratory

A grant of two million pesos from SU-USAID-COE-CRM Marine Laboratory fund was extended to Centrop for the renovation of the interpretive facilities of the A. Y. Reyes Zoological and Botanical Garden which now include an elevated viewing deck and animal enclosures for the Philippine Spotted Deer Information Center. Silliman University's general funds also enabled the renovation of the perimeter fence.

CHED - Funded Field Studies

The collection of field data on the distribution and habitat requirements of the Philippine Spotted Deer from 1997 to date from Barangay Enrique Villanueva, Sibulan was made possible through funding provided by the Commission on Higher Education (CHED). Centrop hopes to publish the preliminary findings from the archived data.

Lubee Foundation - 1992 to date

Through the initiative of Lubee Director, John Seyjagat, support for the project on Philippine Fruit Bat Conservation continues up to this writing (2001). In 1992 and following years, a number of researches have been done on the conservation status and feeding ecology of the fruit bat species in the Philippines.[3] Results of these researches were published in Silliman Journal (1992) and the proceedings of the Symposia of the Zoological Society of London (1995). At present, however, the Lubee Foundation is planning to refocus its thrust toward conservation education campaigns among concerned communities and has encouraged Centrop to redirect its programs' focus in this area.

Funds from Various Sources

With funds from various foreign sources,[4] research activities to survey the remaining wildlife and habitat conditions of the forest in Ayungon, Negros Oriental have been conducted by some faculty and graduate students of the Biology Department in collaboration with a group from the University of the Philippines Los Baños.

STRENGTH, PROBLEMS AND PROSPECTS FOR THE FUTURE

Strength

Centrop's strength lies mainly on the involvement of a succession of scientists who have become connected with the Center since its inception. Up to the present time, Centrop continues to benefit not only from the expertise of these scientists on conservation biology, but also from the support of foreign funding agencies which these visiting scientists bring with them while pursuing research activities in the center. Through the years many domestic and community-based projects of the center have thrived mainly from the support of these research grants.

The pivotal role of the Biology Department as the moving force behind the center's myriad projects is Centrop's other source of strength. In allocating a supplemental budget for maintenance operation, the Biology Department has relieved some of Centrop's financial burdens. Centrop is presently pushing for the inclusion of its maintenance staff's salaries in the University budget.

A. Y. Reyes Zoological and Botanical Garden

The centerpiece of Centrop's achievement over the years is the A. Y. Reyes Zoological and Botanical Garden. It is also the most visible and attractive part of the whole Centrop

system. Named after the late eminent botanist of Silliman University Biology Department, Professor Alfredo Y. Reyes, this facility was then known to everyone as the mini-forest or mini-zoo because it housed 16 species of animals (5 bats, 6 wild pigs, 11 spotted deer) for a total of 62 individuals, in a simulated natural habitat comprising 18 tree species represented by ca 392 individuals. A complete listing of floral and faunal species can be obtained from the Centrop archives.

Funds coming primarily from the USAID-COE CRM Marine Laboratory made possible the renovation of the physical structure for the Spotted Deer Information Center and the completion of the Nature Interpretive facility, including the ground level walkway. Additional funding came from the LUBEE Foundation, FPE, and Silliman University. Construction of the canopy observation tower and the Interpretive Exhibit Panels at the Garden is expected to start soon.

In the last two years (1999-2000) 4,688 people have visited the Botanical Garden, 15.46% of whom were tourists, 59.77% elementary school children, and 24.76% secondary and college students, an average of 43.46 persons/week. The participation of Silliman University Student Organization and Activities Division (SOAD) in organizing tours to this facility continues to attract many visitors to the Garden. Although the earlier figures (1992-1998) were higher, showing about 50-500 visitors/week, not much was done in terms of providing interpretive experience during those years. Since the last 3 years, however, Centrop has been providing visitors not only guided tours of the facility but also an opportunity to exchange ideas with the staff on wildlife conservation at the Centrop Conference hall. The students and their advisers especially profit from this experience. Centrop hopes to develop a visitors' guide that will take into account the interpretive scheme cited earlier to include items such as What the visitors expect to see? How they are expected to interact with what they see? What they expect to learn in terms of wildlife conservation?

The A. Y. Reyes Garden is not only a tourist destination. It is also a place where students at all levels (in the Visayas and Mindanao region) go to develop their thesis proposals on the subject of captive animal behavior; architectural designs for a mini zoo; feeding behavior of captive-bred animals; and, management of captive-bred animals.

Another of Centrop's strengths is the significant contribution it is making in the field of community-based environmental protection, particularly in the aspect of capability building of eight people's organization (POs) in its area of operation in the vicinity of Cuernos de Negros (Mt. Talinis) and the twin lakes area. Among the PO-initiated projects are the development of a working system for the management of their watershed and the introduction of small-scale income generating programs. The Department of Environment and Natural Resources (DENR) has legitimized these activities by certifying some PO members involved in wildlife habitat protection as Deputized Environmental Natural Resources Officer (DENRO). PO membership now numbers 398. Although the primary funding support comes from FPE, other funding and support agencies like LUBEE, FFI, LEAP also provide funding and other forms of support. In return, these agencies make use of PO involvement to carry out their community-based conservation and advocacy activities.

Finally, functioning at present as the research arm of the Biology department and directly under the Office of the Vice President for Academic Affairs, Centrop offers faculty and students an opportunity to engage in research and community outreach activities. Its materials and facilities are likewise utilized by faculty and students of the Biology department for classroom teaching and learning purposes.

Problems

Just like any other unsubsidized research and nature reserve organization, Centrop considers financing a critical problem area. Centrop's viable and continuous existence depends mainly on the material support of donors and funding agencies of approved projects. Given the usual practice of funding agencies of releasing their grants by schedules, the interim period between the last release of funds and the next often causes great financial strain on the staff and personnel who depend on project funds for their salaries. Most often when this happens, the loyal personnel continue working even without compensation. To preempt such predicament, Centrop has been pushing for Silliman University's more involved commitment to the project in terms of providing regular support for the center's maintenance personnel.

Prospects

Centrop's dependence on funding agencies to ensure its institutional survival compels it to widen its research activities and expand its area of operation. To attract more funding or the interest of funding agencies, it must endeavor to continually generate viable projects particularly those along the priority areas supported by the funding institutions' own advocacy activities. Activities such as watershed rehabilitation and sanctuary establishment in the known bat roosting places close to the present area of operation are considered of urgent priority. Therefore a proposal with these thrusts was developed and submitted for funding.

Of some concern to Centrop are the present road building activities in the areas connecting Valencia to Sta. Catalina which pose an imminent danger to dipterocarp trees (*Shorea negrosensis, Pentacme contorta and Shorea polyspema*) as affirmed by DENR. Standing necromass of these dipterocarp species are evident according to a DENR staff, the cause of death is still to be investigated. Mobilization of POs in the nearby areas to protect the remaining dipterocarp species is therefore imperative.

The importance of Centrop's role in advocating and implementing participatory management in all its programs and project activities concerning biodiversity conservation can only be affirmed by tangible results. Translated in concrete terms, this means that in Centrop's area of operation there are now fewer unharvestable trees cut, reduced incidence of kaingin, more tree nurseries developed, less wildlife hunting done and, more importantly, a greater number of people now conscious about protecting their life support system.

CENTROP's Expectations from Silliman University

Centrop's role in providing opportunities to University faculty to get involved in research and extension projects and in enhancing their teaching skills should warrant a stronger commitment of support from the University of its many projects and programs.

NOTES

[1]Authors of these publications, such as Drs. Ely Alcala, Ruth Utzurrum, Louella Dolar, Myrissa Lepiten and visiting researchers William Oliver and Lawrence Heaney were, at one time or another, based at Centrop and Biology department.

[2] The support and participation of FFI in Centrop-initiated projects has been made possible though the help of William L. R. Oliver.

[3] These researches were undertaken primarily by Philippine bat specialist, Ruth Utzurrum.

[4] Funds for these projects were sourced mainly through the initiatives of William L.R.Oliver.

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NOTES ON CONTRIBUTORS

Angel C. Alcala, Ph.D. is a herpetologist by training but he is most widely known for his work in marine ecology. His long and distinguished career straddles both the private and public sectors that continue to feel his enduring influence. He was Silliman University's 6th President before he was called by the Ramos Administration to serve as Secretary of the Department of Natural Resources (DENR). After his term, he became Chair of the Commission on Higher Education (CHED), a position that allowed him to push for the integration of research in the curriculum of Higher Education in this country. Retired from public service, he is currently University Research Director and director of the Angelo King Center for Research and Environment Management at Silliman, a position which gives him all the opportunity to pursue his lifetime passion—research and caring for the environment.

Rafe M. Brown, belongs to the rising crop of young and driven herpetologists of this generation. He is connected with the Section of Integrative Biology and Texas Memorial Museum, at the University of Texas, Austin. At present, he is a Ph.D. student in evolution and behavioral ecology of frogs in the genus Platymantis. His collaboration with Arvin Diesmos and Dr. Angel Alcala on Philippine amphibians and reptiles has considerably enriched the studies on herpetological fauna of the Philippines and enhanced knowledge of reptiles and amphibians not only in this country, but in the Southeast Asian region. He serves as a board member of Haribon and Wildlife Conservation Society of the Philippines and Associate Research Scientist at Silliman University.

Angelita M. Cadeliña, has a Ph.D. in forestry, major in forest resource management from the University of the Philippines in Los Baños. Presently, she is an associate professor at the Biology Department. She is also the Center for Tropical Conservation Studies at Silliman University where, as coodinator, she supervises the first local captive breeding project on the endangered Philippine spotted deer and the Visayan warty pig, the A. Y. Reyes Botanical Garden, and a host of research and community extension programs while feeling very much endangered herself from constant threat of chronic shortage of funding. Her principal research interests are in watershed rehabilitation and management, environmental and socioeconomic impact of infrastructure projects on local population, and soil-water conservation.

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Arvin C. Diesmos finished both his BS Biology in Animal Ecology and MS Wildlife Studies in Wildlife Ecology and Environmental Science degrees at the University of the Philippines, Los Baños. He has taught ecology, systematic biology, and applied biology at De La Salle University-Dasmariñas from 1998-2000. Since 1990, he has led and participated in major biodiversity studies on most of the major islands of the country, from Luzon down to Tawi-Tawi. He is concurrently Associate Research Scientist at the Biological Sciences Department of De La Salle University and the Angelo King Center for Research and Environment Management at Silliman University. Arvin C. Diesmos is a Board Member of the Wildlife Conservation Society of the Philippines, Inc.

Lawrence R. Heaney, Ph.D. is an internationally-renowned expert in Philippine mammals, and one of the most tireless field biologists of his generation and also the most prolific in terms of publication. Heaney anchors his reputation on solid and passionate commitment to research and thanks to his many, mostly groundbreaking studies, inestimable data on bats and other Philippine mammals have become available. Presently, he is Associate Curator and Head, Division of Mammals in The Field Museum in Chicago.

Gerardo Ledesma is the President of the Negros Forests and Ecological Foundation Inc. and the Philippine Reef and Rainforest Conservation Foundation. He is also a member of the Wildlife Conservation Society of the Philippines and Trustee of the Coral Cay Charitable Trust. He is the Project Counterpart for a number of PRRCFI-CCC sponsored projects such as the Danjugan Island Biodiversity Survey, the Negros Rainforest Conservation Project, and the Southern Negros Coastal Development Project which undertakes marine resource assessment of the coastline in southern Negros. He is deeply involved in the NFEFI-CCC collaborative resource assessment and habitat mapping project in the North Negros Forest Reserve, Negros Island.

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