Biogeography & Species Diversity

Overview

Rigorous efforts to measure, conserve and protect global biodiversity require scientists to develop and test a number of research and conservation strategies in the field. These analytical and data-based approaches to conservation demand carefully constructed in-country studies to assess species diversity, distributions, and endemism in threatened ecosystems. The extent to which these species and habitats are adequately protected by current conservation measures must also be assessed.

The CBC’s multi-taxa surveys of flora and fauna were designed to create core research collections to be used for phylogenetic and biogeographic analyses and conservation and management decisions. The study sites and focal taxa were carefully chosen to provide a diverse sample of Vietnam’s threatened biogeographical areas, ecosystems and species to meet these goals. The relationship between these areas and Vietnam’s current network of protected areas, and their potential value as additions to the system, were incorporated into the site selection process.

These research efforts have formed the basis of key impending natural resource and management decisions and will support Vietnam’s future capacity to study and conserve its rich and endangered biodiversity.

Biogeography and Species Diversity

Situated along the southeastern margin of the Indochinese Peninsula, Vietnam covers approximately 329,500 square kilometers from a latitude of 23° N to 8° 30’ N. It is bordered to the north by China, to the west by Laos and Cambodia, and along its eastern coast by Tonkin Bay and the South China Sea.

Vietnam’s north-south orientation of more than 1650km incorporates biogeographic regions ranging from the northern Chinese-Himalayan Paelearctic zone in the foothills of the Himalayas, through the Central Annamite region, to the southern Indo-Malayan Tropical zone. It spans two major delta regions: the Red and Black Rivers in the north and the Mekong River in the south. To the east of the Red River, the limestone ranges of northeastern Vietnam show strong affinities to the flora and fauna of southern China. Along the western border, the Truong Son (Annamite) Mountain Range in central Vietnam forms an important barrier between Vietnam’s moist uplands and the drier monsoon ranges of Laos. Stretching from Lao PDR to the South China Sea at approximately 11° N, the slopes and passes traverse the transition zone between the subtropical north and the tropical south. This unique combination of a strong north-south axis, ecology, geology and climate contributes to Vietnam’s complex assemblage of biogeographic zones, divergent habitat types, and endemic areas.

Origins of Vietnam’s Biota

The rising of the Himalayas over the last 10 million years effectively cut off the exchange of species between the northern Palaearctic and the southern Indo-Malayan realms. This barrier, reinforced by increased climatic cooling after the Miocene, isolated the Indo-Malayan region and created conditions for subsequent species divergence. Recent relatively stable equatorial
conditions, combined with dynamic geological changes, allowed isolated populations to diverge further, contributing to the enormous species richness and high levels of endemism that now characterize Southeast Asia.

Within Vietnam, important topographical and geological features are thought to have contributed to these patterns of species diversity, distribution and endemism. The Red and Black Rivers’ gorges and deltas in the north, and the east-west extension of the Truong Son Range in north-central Vietnam, are considered barriers contributing to the isolation of northern and southern floral and faunal elements. The Truong Son Mountains in central Vietnam along the Laos border are hypothesized to have provided stable refugia for forest-dwelling species during climatic fluctuations associated with the Pleistocene glaciations. This montane fauna has apparently diverged from ancestral forms in the Annamites and northern highlands. Divergent weather patterns across this range - drier and more seasonal to the west in Lao PDR, wetter and more stable along the east in Vietnam - have also contributed to these patterns of endemism, species diversity and distribution.

The biota sampled in the CBC’s multi-taxa survey in Vietnam reflects a divergence between northern elements with strong Sino-Himalayan affinities and southern elements with Indo-Malayan ones. These distribution patterns are coupled with a transition zone in Central Vietnam reflecting an admixture of northern and southern influences as well as high rates of locally-centered endemism and historical patterns of species divergence. Disjunct primate distributions between North and South and the recent discovery of new bird and large mammal species in Central Vietnam (see below) both indicate support for this interpretative framework of Vietnamese biodiversity patterns.

In addition to its direct conservation goals, this multi-taxa survey focused on the Truong Son Range and its transition with the Central Highlands to the south, and on comparative surveys along a North-South transect to gather data testing the hypothesis that these barriers structure patterns of species diversity and endemism.

Biodiversity Research

Past and recent research into Vietnamese biodiversity indicates a species-rich biota and accompanying high levels of endemism:

*Flora*: Vietnam is estimated to have 12,000 vascular plant species (out of 15,000 in Vietnam, Laos and Cambodia, combined), of which approximately 7,000 have been identified. This represents approximately 3.2% of world diversity. In the north an estimated one-third of the flora is endemic, and the country-wide figure is 40%. The most comprehensive account of forest type diversity in Vietnam shows particularly high levels of endemism in the Hoang Lien Son Range, the Da Lat Plateau, and in the northern highlands (Rothe, 1947). Vegetation types include lowland and montane evergreen forests, deciduous Dipterocarp forests, limestone karst forests, littoral forests, and peatswamp and mangrove forests.

*Fauna*: Faunal endemism in Vietnam is the highest in the Indochinese region (MacKinnon & MacKinnon, 1986). Vietnam is known to have at least 160 species of mammals, 723 of birds, 180 of reptiles, 80 amphibians, and over 2,000 species of fish. In Asia, Vietnam ranks highest in fish species richness per unit area, although this figure is based only on data from freshwater fish in the Lower Mekong region. New discoveries are continuing: in the last ten years three new large mammal species, and two new bird species have been discovered in
The Truong Son, along with one hare, five fish species and a tortoise species. This spectacular yield of new species descriptions from this region suggests it is a region of both high endemism and undersampled biodiversity.

The CBC’s multi-taxa survey was designed to conduct inventories on each of these vertebrate groups, as well as on invertebrates and plants, within regions most likely to have high rates of species diversity and endemism.

Conservation Status

Threats to Biodiversity

Vietnam’s natural resources and biodiversity are currently under severe stress. The root cause of these pressures resides in a large and growing population coupled with a continuing dependence on natural resource conversion and exploitation. Pressures on Vietnam’s tropical and sub-tropical forests include high demand for fuel wood for cooking, heating and charcoal production; conversion of land to agriculture; overgrazing and fires; and both official and illegal logging (WCMC, 1994; MacKinnon, 1997). Previous wars have also degraded Vietnam’s forests, particularly the delta mangrove communities. In addition to timber, direct exploitation of forests resources includes the collection of medicinal plants and hunting for both subsistence and the wildlife trade. The sustainability of this exploitation has been reduced by forest fragmentation and degradation and by the increasing commercialization of the wildlife trade, in particular export to China (Compton & Quang, 1998). Finally, Vietnam’s economic outlook is increasingly global; the effect of a developing international economy on natural resource exploitation is not yet clear.

As a consequence of these pressures, Vietnam’s natural forests have been reduced and fragmented. Estimates of closed canopy forest cover (including mangroves) vary from 17.4 to 27.5% of the total land area, of which only one-tenth is likely still in pristine condition (Collins, Sayer & Whitmore, 1991; Wege, et al., 1999). Most of this deforestation is concentrated in lowland areas of the north and south. However, continued population growth and migration into higher elevation areas in central Vietnam (e.g., the Central Highlands) threatens these relatively intact forests through increased agricultural conversion and resource exploitation (WCMC, 1994). Consequences of deforestation include increased flooding, erosion and susceptibility to typhoon damage in coastal areas (Collins, Sayer, & Whitmore, 1991). Fragmentation and degradation directly affect the ability of the forests to support biodiversity, causing a decline in plant resources and wildlife. Additionally, the ecosystem-wide impact of reduced or locally extinct populations of heavily-exploited large-bodied species (e.g., tiger, elephants, gaur) is unknown (Wikramanayake, et al., 2002).

The combination of habitat loss, fragmentation and exploitation directly threatens the survival of Vietnam’s biodiversity. Among vertebrates, bird and mammal extinction rates are estimated to be 100 to 1000 times greater than under natural conditions; similar rates for plants can be expected (WCMC, 1994).

The Protected Area System

Vietnam’s conservation efforts date back approximately 40 years to 1962, when Ho Chi Minh set aside the country’s first national park, Cuc Phuong in Ninh Binh Province, 140 kilometers southwest of Hanoi. But war and its effects on the human population and the
economy delayed further development of an extensive reserve system. At present, a system of 90 protected areas cover approximately 4% of the land area; of these, most are small, isolated, and lack adequate buffer zones. Financial issues, a shortage of trained field staff and managers, and local resource issues have limited the effectiveness of the system.

To protect the country’s remaining biotic diversity, in the late 1990s the government of Vietnam decided to increase the size of the terrestrial protected area system to include 6% of the total land area. Recommendations for expanding the system included removing non-forested areas currently classified as Special-use Forests (protected areas); emphasizing currently under-represented ecosystems (e.g., low elevation Annamite Range Moist Forests); and recognizing the importance of both trans-province and trans-boundary protected areas to national and regional conservation (Wege, et al., 1999; Baltzer, Dao & Shore, 2001). Making these decisions wisely required detailed, reliable information on plant and animal populations, on the status and effectiveness of existing reserves, and on the function of new ones.

At the time, the biodiversity of many of these areas was too poorly known for conservation decisions to be made and subsequently monitored effectively. The CBC-AMNH’s multi-taxa surveys and inventories were part of a response to this need. A shared aim of the collaborators of these surveys was to conduct in-depth and comparative studies of the flora and fauna in unprotected areas experiencing high threats to their biotic diversity.

**Biotic Survey Focal Taxa**

Research into Vietnam’s natural history has had a long albeit sporadic history dating back to the turn of the 20th century. From the late 1800s through the 1930s, historical Indochina (Vietnam, Cambodia, Lao PDR and southern China) was the focus of exploration and natural history collections by primarily French and North American researchers, including Bourret, Coolidge, Delacour and Osgood. Following the Second World War, conflicts and political isolation limited biodiversity research until Russian researchers began working in concert with the Vietnamese in the 1970s following reunification. Recently this region has experienced an explosion of biotic inventory activity, resulting in many new taxa descriptions and geographic range extensions as well as exploration of the factors underlying species diversity and distribution patterns.

Renewed interest in Vietnamese biodiversity can be partly attributed to the fact that, despite this extensive historical activity, a number of geographic regions and important floral and faunal groups remain virtually unknown. Previous work has concentrated on generally well-known groups (birds, large mammals) and inventories of organisms such as vascular plants and freshwater fishes frequently consist of unverified checklists based on site observations. Comprehensive surveys of other taxa, including well-characterized ones, underrepresent large sections of the country, e.g. the extensive area east of the Red River in northern Vietnam.

The joint CBC-AMNH/IEBR/MBG research expedition surveyed six focal taxa in three regions of Vietnam: amphibians and reptiles, birds, freshwater fishes, invertebrates, mammals and vascular plants (flora). These taxa and focal groups within them were selected because they met one or more of the following key criteria:
- Scientists at the American Museum of Natural History, Missouri Botanical Gardens, and the Institute for Ecology and Biological Resources are specialists in the groups;
- Additional collections will contribute to phylogenetic studies and knowledge of biogeography, species richness, and distributions;
- Combined they can provide a cross-section of overall diversity for assessing the richness and conservation status of a region; and
- Collecting techniques suitable for comparative analyses are available for each group.

A brief summary of historical survey work, knowledge at the time of the survey, and focal groups for each of the following taxa are provided below.

**Arthropod Biotic Surveys**

Invertebrates are the most diverse group of animals on earth and can provide an enormously rich data set for analyzing patterns of species richness, distribution and diversity across a variety of gradients. They can also be readily collected using standard protocols, allowing for robust comparative analyses between research sites. The following taxa within invertebrates were selected to provide a cross-section of arthropod diversity and because they met the other focal taxa requirements:

- **Arachnida**: Ctenidae (wandering spiders)
- **Heteroptera**: Reduviidae (ambush or assassin bugs)
- **Coleoptera**: Staphylinidae (rove beetles)
- **Hymenoptera**: social Vespidae (wasps) and Braconidae (parasitoid wasps)
- **Diptera**: Mycetophilidae (fungus gnats) and Drosophilidae (fruit flies)

Estimates of global insect species diversity vary greatly, running from a low of 1.84 million to more than 50 million total species. In large part this uncertainty reflects our poor knowledge of the ecological and evolutionary processes structuring speciation and the maintenance of diversity in these groups. Current consensus figures lie between 4 and 10 million species, approximately 1 million of which have been described to date. Compiling accurate lists of currently known taxa and estimating true invertebrate diversity totals for individual countries is difficult.

In addition to uncovering novelty, a survey of arthropods can be a useful tool in biodiversity and conservation research. The high diversity of anthropods and our ability to sample large numbers of taxa and individuals using standardized protocols makes this an excellent research group for a variety of comparative analyses. These include examinations of local community structure, species distribution across elevational, climatic and latitudinal gradients, and biogeographical hypotheses of species diversity patterns. Results from this research address basic ecological and evolutionary questions and also inform conservation and protected area management plans.

The Center for Biodiversity and Conservation at the American Museum of Natural History in New York and the Institute for Ecology and Biological Resources in Hanoi jointly surveyed arthropod biodiversity in three regions of Vietnam, 1998-2000. This research was intended to estimate overall species richness and faunal turnover along altitudinal gradients and to measure the diversity and distribution of organisms and identify new taxa in the focal groups. Methods were designed to allow comparative analyses between sites and to assess the conservation and biodiversity value of these currently unprotected areas.
Herpetology Biotic Surveys

Large-scale survey work on Vietnamese herpetofauna essentially ceased between 1945 and the 1990s and, with a few exceptions, regional monographs on Indochinese amphibians and reptiles pre-date the Second World War. The species diversity and conservation status of amphibian and reptile taxa in this region are interesting for a variety of reasons. First, recent survey work in Vietnam indicates potentially high levels of hidden biodiversity in anuran species complexes (e.g., ranids, rachophorids). Assessing amphibian species richness and endemism requires taxonomic revisions based on both on-going surveys and existing natural history collections. Second, snakes and especially turtles are under intensive harvesting pressure to supply local and regional markets, creating an urgent need for information on the diversity, ecology, taxonomy and conservation status of these taxa.

Current estimates of herpetofauna diversity in Vietnam name approximately 100 amphibian and 180 reptile species, a relatively high proportion of which (20 to 25%, est.) are either endemic to Vietnam or occupy restricted ranges in the region. One amphibian (the endemic Vietnamese Salamander, Paramesotriton deloustali) and 27 reptile species (primarily turtles) are listed as Vulnerable, Endangered or Critically Endangered by the IUCN (2000).

The Center for Biodiversity and Conservation (AMNH) and the Institute for Ecology and Biological Resources in Hanoi surveyed amphibian and reptile biodiversity at three sites in Vietnam, 1998-2000. In addition, a brief pilot study was carried out in 1997. The research was designed to assess the degree and distribution of species diversity, identify new taxa and range extensions, and assess the conservation importance of these currently unprotected areas.

Ichthyology Biotic Surveys

Freshwater ichthyofauna is under-surveyed and under-described throughout Indochina. Current checklists of fishes from Northern and Southern Vietnam are believed to represent approximately 80% of actual diversity, and of these roughly 50% of taxa descriptions consist of single known localities and associated habitats. Fauna inhabiting streams draining the eastern slopes of the Annamite Cordillera to the Gulf of Tonkin are particularly poorly known, although there is evidence of distinct biogeographic affinities north (to taxa found in the Red River Delta and South China) and south (to taxa in the Mekong Delta) of the Hai Van Pass, c. 16° N. The CBC’s multi-taxa surveys helped to clarify existing nomenclature and contributed to surveying and monitoring protocols.

Tropical Asia and Southeast Asia host a rich freshwater fish fauna numbering over 3,000 species in 121 families (including 18 regional endemics). Despite this high recorded biodiversity, Southeast Asia in general and Vietnam in particular remain both under-surveyed and under-described. This is especially true of the river basins draining the eastern slopes of the Truong Son Mountains along the Vietnam-Lao PDR border. Roughly 450 fish species are currently known from the inland waters of Vietnam, a list which constitutes (at best) 80% coverage of extant freshwater ichthyofauna biodiversity. The need for further exploration and conservation assessments coincides with expanding threats to freshwater resources from flow alteration and water diversion, increased sediment load, introduced species, overfishing and habitat loss. Currently seven species of freshwater fish occurring in Vietnam have been placed on the IUCN Red List (2000), including Mekong Freshwater Stingray Dasyatis laosensis, the regionally endemic Giant Mekong Catfish Pangasianodon gigas, and
Asian Arowana *Scleropages formosus*, restricted in Vietnam to the east slopes of the Truong Son Mountains. This is clearly an incomplete assessment of Vietnam’s threatened freshwater fish species.

The Center for Biodiversity and Conservation at the American Museum of Natural History in New York and the Institute for Ecology and Biological Resources in Hanoi, jointly surveyed freshwater ichthyofauna at three locations in Vietnam, 1998-2000. Research was designed to record the diversity and distribution of freshwater fish species, identify new taxa, record range extensions, provide baseline data for monitoring freshwater ecosystem health, and assess the conservation and biodiversity value of currently unprotected areas.

**Mammalogy Biotic Surveys**

Large mammals are the most intensively and extensively surveyed group in Vietnam and the fauna contains a number of important taxa, including four endemic, globally threatened primate species and three recently described artiodactyles. To complement this work, the CBC-AMNH/IEBR surveys chose to focus on small mammals, bats and insectivores. Apart from Osgood’s 1932 survey of Indochinese mammals, research into the diversity and distribution of these taxa has been limited and there are few modern survey protocols and identification guides available. Small mammal surveys can potentially provide both baseline and monitoring data on species richness and distribution and information on overall ecosystem health using standardized collection methods. This approach is especially useful in countries such as Vietnam where moderate habitat disturbance and intense human exploitation of the large mammal fauna can make conservation assessments challenging.

A diverse assemblage of over 200 mammals inhabits Vietnam, reflecting the intergradation of Sino-Himalayan and Indo-Malayan biogeographic zones and the presence of a regionally endemic fauna centered on the Truong Son Mountains. It includes five recently discovered or re-discovered mammals with distributions limited to a subset of Indochina (including Vietnam): Heude’s Pig *Sus bucculentus*, Large-antlered *Muntjac Muntiacus vuquangensis*, Annamite *Muntjac M. truongsonensis*, Roosevelts’ *Muntjac M. rooseveltorum* and Annamite Striped Rabbit *Nesolagus timminsi*. This burst of research into Vietnam’s complex species diversity has coincided with increasing threats to its conservation. Threatened taxa include four species on Conservation International’s list of the twenty-five most endangered primates in the world: Delacour’s Langur *Trachypithecus delacouri*, Cat Ba Golden-headed *Langur T. poliocephalus*, Gray-shanked Douc Langur *Pygathrix cinerea* and Tonkin Snub-nosed Monkey *Rhinopithecus avunculus*. Exploitation, habitat loss and human activity also threaten the less visible small mammal species critical to overall ecosystem health.

The Center for Biodiversity and Conservation at the American Museum of Natural History in New York and the Institute for Ecology and Biological Resources in Hanoi jointly surveyed small and large mammals in the Northern Truong Son Mountains in 1998 and 1999. Research was designed to assess species richness and distribution, record threatened species, identify new taxa and range extensions, provide baseline data for monitoring ecosystem health, and assess the conservation and biodiversity value of this currently unprotected area. Complementing the field research, Darrin Lunde from AMNH (now at the Smithsonian National Museum of Natural History) and Nguyen Truong Son from IEBR collaborated on the fully-illustrated “Identification Guide to the Rodents of Vietnam” (2001). The guide includes a taxonomic key to Families and diagnosis of Subfamilies in the Order Rodentia, species...
range maps, natural history notes, and information on preparation, curation and collections management techniques.

**Ornithology Biotic Surveys**

The avifauna of Vietnam and the surrounding regions has been the focus of exciting and productive scientific investigations for more than eight decades. The French ornithologist and natural historian Jean Delacour undertook seven major research expeditions to Indochina between 1923 and 1939, five of which visited present-day Vietnam. More recent activity has identified three new montane passerine taxa from the Kon Tum Plateau and four Endemic Bird Areas are now recognized in Vietnam. Despite the intensity of previous work we included birds in the focal taxa because the fauna is well-described, they are generally diurnal, obvious and easily surveyed, and new taxa and range extensions are still being uncovered. Their distributions are also likely to help clarify how the intergradation of subtropical and tropical biota across latitudinal and altitudinal gradients structures observed biodiversity patterns.

Current estimates place the number of bird species present in Vietnam at nearly 850. Sixty-three of these—over 7%—are classified as either Globally Threatened or Near Threatened. In the last five years, three new montane passerine species have been described from the Central (or Western) Highlands of Vietnam: Golden-winged Laughingthrush *Garrulax ngoclinhensis*, Black-crowned Barwing *Actinodura sodangorum*, and Chestnut-eared Laughingthrush *G. konkakinhensis*. These novel species and the identification of a number of new subspecies and range extensions from throughout the country suggest that the extent and distribution of Vietnam’s avifauna requires further study.

The Center for Biodiversity and Conservation at the American Museum of Natural History in New York and the Institute for Ecology and Biological Resources in Hanoi jointly surveyed avifauna at three research sites in Vietnam during 1999 and 2000. Research was designed to assess species richness and the distribution of biodiversity, note the presence of threatened species, identify new taxa and range extensions, and assess the conservation and biodiversity value of these currently unprotected areas.

**Flora**

Vietnam’s floristic diversity is high given the country’s size. Approximately 12,000 vascular plant species are predicted to occur in the country, fewer than 8,000 of which have been identified; 10% of these species and 3% of the genera are believed to be endemic. Diversity patterns across latitudinal and altitudinal gradients are often complex, reflecting the admixture of sub-tropical and tropical biota and Vietnam’s complex geology, topography and climate.
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