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Source: Ornithological Monographs No. 70

Published By: American Ornithological Society

URL: https://doi.org/10.1525/om.2011.70.1.1

Ornithological Monographs
Volume (2011), No. 70, 1–9

CHAPTER 1

BIRD SPECIES-RICHNESS PATTERN IN THE GREATER HIMALAYAN MOUNTAINS—A GENERAL INTRODUCTION

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Abstract.—Any analysis of species distributions in Southeast Asia must confront several difficulties, including weak baseline data, a coarse sampling grid, and confused taxonomy. A critical portion of this region, namely the southeastern Himalayas and associated sub-Himalayan areas, are high in species richness and yet are poorly sampled or understood from an ornithogeographic and conservation perspective. Recent surveys in Assam, Arunachal Pradesh (northeast India), Yunnan (southwest China), and Kachin State (northern Myanmar) have revealed new taxa, confirming the hypothesis that the mountain range is of global conservation importance. In this monograph, we summarize current knowledge, historical and recent collection activities, and taxonomic, systematic, and biogeographic revisions and consider the need for additional work and where in the region that work should be focused.

Key words: Arunachal Pradesh, Assam, biogeography, bird collection, bird surveys, birds in Asia, Himalayan Mountains, Kachin State, northeast India, northern Burma, northern Myanmar, phylogeography, south Tibet, southeastern sub-Himalayan Mountains, southwest China, species-richness pattern, systematics, taxonomy, Yunnan.

အနှစ်ချုပ်။ ။ အရှေ့တောင်အာရှဒေသအတွင်းရှိ မျိုးစိပ်များ ပြန့်နှံ့မှုဆိုင်ရာ လေ့လာဆန်းစစ်ခြင်းတိုင်း သည်၊ အားနည်းသောအခြေခံစာရင်းဇယားများ၊ ချွတ်ယွင်းချက်များရှိသော နမူနာစာရင်းကောက်အကွက်များ နှင့်၊ မှားယွင်းရှုတ်ထွေးစွာ မျိုးခွဲထားမှုများ၊ စသည့်အခက်အခဲများဖြင့် မုချရင်ဆိုင်ရမည် ဖြစ်ပေသည်။ ဤဒေသတွင်းရှိ အရေးကြီးအပိုင်းများဖြစ်သော၊ ဟိမဝန္တာ အရှေ့တောင်ပိုင်းဒေသများ၊ ယင်းနှင့်ဆက်စပ်နေသော အနိမ့်ပိုင်း ဟိမဝန္တာတောင်ကြောဒေသများတွင်၊ မျိုးစိပ်ကြွယ်ဝမှုများပြားလှသော်ငြားလည်း၊ သဘာဝထိန်းသိမ်းရေးဆိုင်ရာ ရှုထောင့်မှသော်၎င်း၊ ငှက်များပြန့်နှံ့မှုဆိုင်ရာ ပထဝီဝင် ရှုထောင့်မှသော်၎င်း၊ သိရှိနားလည်ထားခြင်းများ၊ သို့မဟုတ် နမူနာစုဆောင်းထားရှိခြင်းများမှာ နည်းပါးလှပါသည်။ မကြာသေးမီက အာသံနယ်၊ အရွန်နာချယ် ပရာဒေ့(ရှ်) (အိန္ဒိယနိုင်ငံ အရှေ့မြောက်ပိုင်း)၊ ယူနန်နယ် (တရုတ်နိုင်ငံအနောက်တောင်ပိုင်း)၊ နှင့် ကချင်ပြည်နယ် (မြန်မာနိုင်ငံ မြောက်ပိုင်း) တို့တွင်ပြုလုပ်ခဲ့သော၊ ကွင်းဆင်း လေ့လာဆန်းစစ်မှုများမှ၊ တောင်တန်း တောင်ကြောများသည် ကမ္ဘာ့ အရေးကြီးဒေသများ ဖြစ်သည် ဟူသောအယူအဆအား ပိုမို ခိုင်မာစေသည့် မျိုးစိပ်သစ်များ တွေ့ရှိခဲ့ခြင်းကို၊ ထုတ်ဖော် ကြေငြာခဲ့ပြီးဖြစ်ပါသည်။ ဤစာတမ်းတွင် လက်ရှိသိနားလည်ထားခြင်းများ၊ လတ်တလော နမူနာစုဆောင်း ထားရှိခြင်းများ၊ နမူနာစုဆောင်းထားရှိခြင်းသမိုင်းကြောင်းများ၊ မျိုးခွဲထားမှုစနစ်များနှင့် ဇီဝပထဝီဝင်ဆိုင်ရာများအား၊ ပြန်လည်သုံးသပ် ပြင်ဆင်ထားခြင်းများကို၊ ထုတ်နှုတ်တင်ပြထားပါသည်။ ထို့အပြင် အနာဂါတ်တွင် လုပ်ဆောင်ရမည့်လုပ်ငန်း လိုအပ်ချက်များ နှင့် ဦးစားပေးအလေးထား လုပ်ဆောင်သင့်သည့် ဒေသတွင်းမှ ဒေသနေရာများကိုလည်း၊ ထည့်သွင်းစဉ်းစားထားပါသည်။

Worldwide, birds are probably the best-studied clade in any scientific collection (Chapman 2009, Global Biodiversity Information Facility 2010; see Chapter 8 of the present volume), and collecting effort is ongoing (Remsen 1995). Nevertheless, global efforts of active bird collecting are declining and all bird collections are spatially biased, often with a particular geographic focus (Global Biodiversity Information Facility 2010). A few areas are covered very well, such as the Americas, Australia, and Europe. Others are poorly sampled, if sampled at all (Fig. 1A).

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Ornithological Monographs, Number 70, pages 1–9. ISBN: 978-0-943610-86-3. DOI: 10.1525/om.2011.70.1.1.

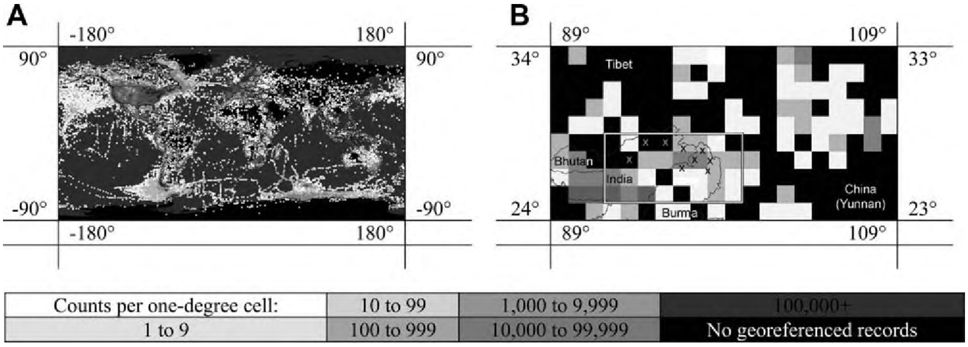

FIG. 1. Georeferenced records of Aves available through the Global Biodiversity Information Facility on a coarse one-degree basis as a proxy of availability of specimens (A) on the global scale and (B) in our approximate study area (rectangle). Reproduced with kind permission of the Global Biodiversity Information Facility (2010). Note: If not-yet-georeferenced specimens from collections were added, the image would not change visibly, because most records are from localities already represented. One-degree cell coverage represents patchy distribution of georeferenced records within each cell. Counts and records are mostly from one or two localities within each cell.

One of these areas with low representation in collections is the southeastern Himalayan and sub-Himalayan region of northeast India, extreme northern Myanmar (the former Burma), southern Tibet, and western Yunnan (China; Fig. 1B). To date, there are only ~9,900 georeferenced online records of birds from the area; by comparison, an area of similar size within the United States has in excess of 1 million georeferenced records (Global Biodiversity Information Facility 2010; Fig. 1).

The symposium "S19: Biogeography of Birds in the Southeastern sub-Himalayan Mountains—Center of Endemism or Many Species in Marginal Habitats?" was held at the joint meeting of the American Ornithologists' Union, the Cooper Ornithological Society, and the Society of Canadian Ornithologists–Société des ornithologistes du Canada in Portland, Oregon, on 7 August 2008. It addressed topics of considerable interest and importance from both scientific and conservation perspectives. The information contained in that symposium and consideration of critical questions posed during discussion are included in the present volume. The past decade has seen the discovery of many new taxa of plants, reptiles, amphibians, mammals, and birds from the region. The discovery of new species throughout all groups of organisms, but in particular the avifauna, demonstrates that the southeastern sub-Himalayan region is one of the most diverse and least explored parts of the world. New taxa in combination with new insights into species' distributional ranges and ecology are important for understanding the three major biogeographic regions (Holarctic–Palearctic, Indian subcontinent, Southeast Asia) that overlap in the southeastern sub-Himalayan Mountains.

Chapters 2, 3, 5, and 8 of this monograph summarize and discuss species-richness patterns and occurrence in different parts of the region and different seasons. Chapters 4, 6, and 7 provide in-depth reviews of emerging issues in taxonomy and species distributions in the area and assess past ornithological research and exploration in the region. These latter contributions have been assembled after the symposium. This *Ornithological Monograph* summarizes historical and current ornithological research and surveys in the region. On this basis, we draw some conclusions regarding the current status of our understanding of the region in terms of its ornithogeography and provide suggestions for future research directions.

Geography, Climate, and Vegetation

The present volume covers roughly the provinces of Arunachal Pradesh and Assam in India, northern Kachin State in Myanmar, southern Tibet, and western Yunnan in North China (Fig. 2). However, the area extends westward into the actual Himalayan ranges. Many species that occur in the area are found elsewhere, and some are cosmopolitan.

The "actual" Himalayan Mountains are defined as the ranges westward of the Brahmaputra in

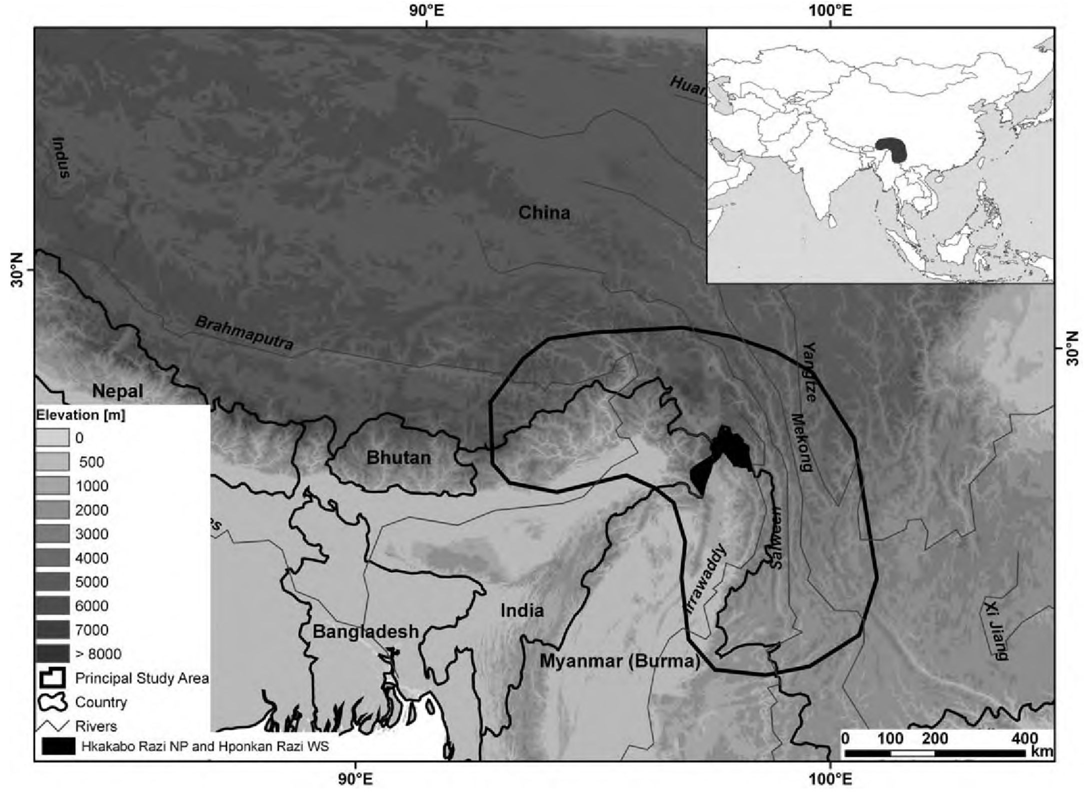

FIG. 2. Maps showing our area of interest (bold polygon).

India and the tributaries in Tibet, passing through Bhutan and Nepal. Any mountain ranges east of the Brahmaputra are here considered the "southeastern sub-Himalayan Mountains" (our area of interest) of Southeast Asia; these extend as far south and east as the Hengduan Shan in Yunnan and Sichuan; in fact, the southeastern sub-Himalayan Mountains overlap partly with the Gaoligong Shan (see Chapter 3). Sometimes, even the northern mountains of Vietnam are considered part of the Himalayas (Mount Fan Si Pan, Fansipan or Phan-xi-păng, 3,143 m, 22.2492°, 103.8333°), but we here apply the previous definition. All the Himalayan, sub-Himalayan, and adjacent mountain ranges to the west, east, north, and southeast are considered here as the Greater Himalayan Mountains.

Geography and climate in the region are extremely diverse, and this diversity gives rise to the extraordinary species diversity in the region. The terrain is steep, with slopes often exceeding 45°. Within <100 km from south to north, the elevation rises from ~420 m in the Assam and Putao plains (localities in Kachin State, as in Chapter 6 of the present volume) to >5,882 m at the top of Mount Hkakabo Razi in Myanmar, and even higher in the Himalayan Mountains (>8,000 m). Compared with this short distance, it is 1,300 km from Putao to the delta of the Ayeyarwady (southwest of Yangon; synonymies of all names from Myanmar are given in Chapter 6). Several major climate zones occur, including tropical to subtropical broad-leafed evergreen forest, temperate forest, high-elevational *Pinus–Rhododendron* forests, bush and shrub vegetation, boulder, and cold-temperature desert-like habitats and glaciers (Renner et al. 2007). This extreme climate zoning and the steep elevational gradient provide a large number of different habitats. The diverse vegetation cover, in turn, accounts for at least some of the high zoological diversity.

Concepts of High Species Richness, Endemism, and Speciation

The species richness in the southeastern sub-Himalayan Mountains is high (see Chapter 8), especially for a temperate region. We do not know whether the high bird diversity in the sub-Himalayan Mountains originates from overlapping distributional ranges (the explanation provided by Mayr [1942, 1999] and Stanford and Mayr [1940, 1941a, b, c, d]; cf. Stattersfield et al. 1998; Rabinowitz et al. 1999; Renner et al. 2007, 2008, 2009), high levels of endemism (Stattersfield et al. 1998), elevational gradients (compare Rahbeck 2005), influx of species from Southeast Asia (e.g., Price 1991, Alström et al. 1997, Päckert et al. 2005, Johansson et al. 2007), or paleo-refuges (cf. Haffer 1969, 1974, 1997, 1998). These competing concepts differ in the level of their analysis and their applicability, in terms of the environment, to our area of interest. Some of the concepts involve several explanatory variables (e.g., elevational gradients and gradients of primary production), whereas others focus on patterns of distribution alone. Several concepts are old and have been replaced by newer concepts. Below, I summarize some findings and concepts that are relevant to a better understanding of the principal scientific question addressed in the present volume.

(1) Zoogeographic regions generally have indistinct boundaries derived from past or current geomorphological separation as well as a broad range of specific environmental characteristics, such as temperature and primary production. Thus, a significant portion of the fauna within each region has similar distributional ranges, which differ from those of species in other regions (Horton 1973, Cox 2001, Cox and Moore 2005). Changes in species composition (i.e., species turnover) occur between adjacent zoogeographic regions within a comparatively short distance (turnover area, or area of overlap). Each of these regions has a specific species composition, which is distinctive from those of other zoogeographic regions (Cox and Moore 2005). This geographic distinctiveness can be observed globally and regionally in almost all faunal groups, but it has been analyzed particularly in mammals, birds, vascular plants (Cox and Moore 2005), and beetles (W. Schawaller pers. comm.).

Species turnover between zoogeographic regions (here, boundaries between zoogeographic regions) has been debated for some groups, and the delineation of the regions remains indeterminate and consists of zonal overlap (Holloway 2003a, b). Zoogeographic regions were established for many faunal groups during the past century in an iterative process (Cox and Moore 2005). However, zoogeographic area analysis has been useful for inferring the role of vicariance barriers such as major mountains and rivers in biogeography, especially the role of the Himalayas in separating and defining the Indo-Malay zoogeographic region and the Palearctic region. It has been less useful in explaining recent speciation events and for examining local areas of high species diversity. However, birds, in particular, can travel large distances or disperse and settle easily and quickly in new habitats, potentially obscuring the accepted boundaries of these zoogeographic regions.

(2) "Biodiversity hotspots" (Myers 1988, Mittermeier et al. 1998, Myers et al. 2000) are areas with high numbers of plants that are endemic to a small area. Levels of threat and rates of endemism of birds, mammals, amphibians, and reptiles serve as supporting data (Mittermeier et al. 1998) and are used mainly by Conservation International as a concept in conservation prioritizing and fund-raising (Myers et al. 2000). Similarly, the "endemic bird areas" of BirdLife International focus on birds that are endemic to a small area and identify regions with at least two restricted-range species (<50,000 km^2) or endemic birds to argue for the region's significance for conservation action (Stattersfield et al. 1998). There are currently three biodiversity hotspots overlapping with our area of interest: "Indo-Burma," "Himalaya," and "Mountains of southwest China" all occur in the Greater Himalayan Mountains (GIS shapefiles of the biodiversity hotspots are available online; see Acknowledgments). In addition, the endemic bird areas "Eastern Himalayas" (no. 130), "Northern Burmese Lowlands" (no. s079), and "Yunnan Mountains" (no. 139) cover similar areas as the biodiversity hotspots (Stattersfield et al. 1998). The point of convergence for these various measures of species richness is in the southeastern sub-Himalayan region of northern Myanmar and northeastern India.

Hotspot concepts mainly identify high-priority areas in conservation and do not specifically address any ecological or phylogenetic question beyond current distribution. High levels of speciation and endemism are taken as starting observations. Underlying processes (high speciation rates, low extinction rates) or explanations of why these situations occur are not the purpose of the concept, because it is not strictly necessary for conservation action or to engage the general public.

(3) Broad-scale species-richness gradients aim to explain why a certain number of species is

found at any given place within a large area, such as mountain ranges or continents (see Chapter 3). Broad-scale species-richness gradients focus less on specific geographic areas but are rather spatially implicit (e.g., Hawkins and Agrawal 2005, Rahbeck 2005). The gradients have been identified latitudinally, elevationally, or both. Broad-scale gradients are often correlated with variables such as energy (radiation or primary production is typically used as a proxy for energy), water availability, or elevation, but ignore—at least so far—phylogenetics, inter- or intra-specific competition, speciation events, and the geomorphological history of a region (Hawkins et al. 2003a, b; Jetz et al. 2004; Hawkins and Agrawal 2005; Rahbeck 2005; Johansson et al. 2007). The latter would be essential for explaining the east–west "gradient" in our area of interest.

Biogeographers are searching for factors or parameters that can explain species-richness gradients or areas of high endemism (e.g., Fjeldså et al. 1999; Hawkins et al. 2003a, b; Jetz et al. 2004; Dillon and Fjeldså 2005; Hawkins and Agrawal 2005). These parameters are unfortunately very hard to identify, because the patterns are large-scale and the data needed for a suitable analysis are either very expensive or not available. The latter is especially true for the original data on birds in the Greater Himalayan region (compare below), where baseline data in some of these areas have simply not yet been collected. Hence, most broad-scale species-richness-gradient analyses focus on the Western Hemisphere, for which better data sets are available.

(4) Another explanation for high species numbers in mountain areas is based on variation in elevation (e.g., Jetz et al. 2004, Johansson et al. 2007), which presumes that each species has a more-or-less narrow elevational habitat range. The steep elevational incline from south to north in the Greater Himalayan Mountains can explain some species richness. Species' ranges are limited latitudinally and elevationally in the eastern Himalayan and southeastern sub-Himalayan Mountains, and both effects are especially visible here. Many species have a northern or southern range limit in our area of interest. Several species (the same or others) occur in lower elevations and have an upper limit in mid-elevations or occur in higher elevations and have a lower limit in mid-ranges. Several species are primarily distributed in mid-elevations. The main overlap in regard to elevation is in mid-elevations and forms a peak of species numbers (e.g., Price 1991 for warblers in India; Chapter 3 of the present volume for species in the Gaoligong Shan; Chapter 8 for species limits in regard to latitudinal and east–west distribution), but this factor alone cannot explain the high species richness per se.

Besides the above-mentioned prominent north–south latitudinal and elevational gradient in our area of interest, the east–west axis is less characterized by one short-distance elevational gradient (note, however, that elevation undulates considerably from east to west). The elevations rise less steeply from east (South China Sea) to west along the Himalayan ranges (Fig. 2) and eventually alternate between mid- and high-elevation extremes (4,000 to >8,800 m) along the mountain ranges within Myanmar, India, Bhutan, Tibet, and Nepal. This elevational gradient is less steep than the north–south gradient, and the species turnover from east to west needs further analysis and explanation.

Elevational gradients in species richness are easy to detect for some groups, especially for plants. However, for mobile organisms such as birds, the elevational packaging remains fuzzy, and sharp boundaries are hard to establish. High species richness in medium elevations may indicate that many species from low and high elevations have marginally overlapping elevational ranges in the mid-elevations.

(5) Other researchers focus on the spatiotemporal origin of clades by influx. For example, ancestors of *Phylloscopus* and *Seicercus* have been postulated to originate in southeastern continental Southeast Asia; younger members of the clade have been moving to northeastern Southeast Asia. Hence, a considerable part of the avifauna is hypothesized to have originated from an influx of species from southeastern Southeast Asia via the southeastern sub-Himalayan Mountains into the Himalayas (e.g., Price 1991, Martens and Eck 1995, Alström et al. 1997, Alström and Olsson 1999, Johansson et al. 2007). Such an influx could explain the distribution of several species in the Himalayas as well as in tropical lowlands of India and Southeast Asia (Martens and Eck 1995, Rasmussen and Anderton 2005). According to Martens and Eck (1995), warblers of the genera *Phylloscopus* and *Seicercus* most likely emigrated from the east into the Himalayan Mountains. So far, findings for these two genera have not been confirmed for other clades from our area of interest. In fact, there are few data from some taxa in

the genera *Parus* and *Certhia* of sufficient detail to support such findings (see Chapter 4).

The influx theory is relatively new. The Himalayan Mountains have probably had many speciation events, and influx is an additional way to account for the high levels of species diversity. However, it should be noted that there are also findings from many clades in the Andes that contradict such a simple account (e.g., Fjeldså 1985). The contradictions are currently unresolved, and only new data from the field and further analysis regarding the influx theory will help us understand the origin of Himalayan Mountain clades (compare the findings in García-Moreno and Fjeldså 2000, Fjeldså and Rahbeck 2006, and Chapters 4 and 8 of the present volume).

Objectives and Goals

In light of the concepts and hypotheses discussed above, the following are the major questions and statements of this monograph:

- Is the level of endemism low in the Himalayas compared with other globally important mountain systems, such as the Andes? How many species are distributed in the Himalayan Mountains and the southern lowlands? Do current findings on endemic species in the eastern Himalayan Mountains and extreme northern Kachin State contradict previous findings of low endemism in the southeast sub-Himalayan Mountains (cf. Rappole et al. 2005, 2008; Athrya 2006; Chapter 2 of the present volume)?
- In addition, are the southeastern sub-Himalayan Mountains a center of high endemism or immigration? Most analyses of the Himalayan avifauna have examined clades that are distributed mainly in the Palearctic (e.g., warblers and tits), as well as many migrant species that are also mainly from the Palearctic. Comprehensive analyses of clades from continental Southeast Asia and clades with many more taxa within the Himalayas are lacking (see Chapter 4).
- What are the implications of taxonomy for conservation in the region? It is important to understand the taxonomy, because whether a population is regarded as a species or as a subspecies makes a difference in conservation. Depending on these findings, conservation approaches and target areas may vary significantly. Whether endemism in the Himalayas is high or the result of many marginal overlapping species ranges dictates very different approaches to conservation (see Chapters 3 and 8).
- What areas need more sampling to address the most critical research questions (see Chapter 6)? What seasons are especially underrepresented by sampling in the region (see Chapters 2, 5, and 7)?

Although the aforementioned north–south elevational gradient at least contributes to the high diversity found in the area, species-richness turnover from east to west may require a different explanation (Stanford and Ticehurst 1935a, b, 1938a, b, c, d, 1939a, b; Stanford and Mayr 1940, 1941a, b, c, d), or at least further theoretical support besides the mere elevational gradient. Concepts and studies that explain diversity patterns are frequently published (see above), but all recognize a considerable knowledge gap with regard to South Asia, Southeast Asia, or both (e.g., Rahbeck 2005; cf. Global Biodiversity Information Facility 2010). Hence, to contribute to diversity distribution concepts and analyze species distribution in the region, some further prerequisites need to be fulfilled:

- Revision of taxonomy of the avifauna (Rahbeck 2005), specifically addressing "over-lumping" of genera and species (Peterson and Moyle 2008) as well as revising systematics and taxonomy of almost all groups. This problem is especially critical for Southeast Asian ornithology, given that a thorough, general revision of taxonomy and systematics has not yet been accomplished and will not be finished soon (Peterson and Moyle 2008). Such revisions have been done for the Western Hemisphere or Europe. Recent efforts to start on such endeavors are still ongoing, and results are so far not congruent (compare summary in Chapter 8).
- Complete biogeography to establish the spatiotemporal origin of the region's clades.
- Compile range maps for the occurrence of all taxa that are based on confirmed records (vouchers or specimens).
- Fill collection gaps to support species distributions and speciation hypotheses with new material (i.e., specimens).

All the chapters of this monograph reflect, in different ways and to different extents, the current knowledge. They will help reduce significant gaps in our knowledge and provide focus for future collection activities and research on biogeography, phylo-biogeography, systematics, and taxonomy. All of the contributions address the question of species richness on a local scale and contribute to developing an understanding on the regional scale (the Himalayan and sub-Himalayan Mountains). Although we intend to summarize and present new insights, we cannot finally answer the question of which species-distribution concept is most important for the area (because of data deficiency). Still, we provide a synthesis of the results currently available in Chapter 8.

Challenges and Consequences for Conservation

The analyses and results presented in this monograph have some implications for conservation and global species distributions. Myanmar is one of the countries with the largest expanse of remaining forest in the Asia-Pacific region (Dinerstein and Wikramanayake 1993, Leimgruber et al. 2003), with most of the almost untouched habitat occurring in the northern and central parts (i.e., Kachin State and Sagaing Division in the north and Bago in the central mountain ranges). Two of the country's largest protected areas, Hkakabo Razi National Park (established on 12 November 1998; 2,500 km^2) and Hukaung Valley Tiger Reserve, have recently been designated through the efforts of conservation agencies, and two additional sites that connect and expand this entire protected complex include Hponkhan Razi National Park and Sumphabum Wildlife Sanctuary. As indicated above and explained elsewhere (e.g., Chapter 2), the total area north of Putao and within Kachin State is unique, because bird diversity is high and high mammal, butterfly, reptile, and leach diversity also occur, as well as incredible diversity in plants (e.g., Khin and Aung 1999, Shwe et al. 1999, Lwin and Thwin 2003, Renner et al. 2007; see Chapters 2 and 3 of the present volume). Additionally, especially in the Nam Tamai valley, the cultural diversity of *Homo sapiens* may be unique in global terms, given that within <100 km, Tibetan, Rawa (Ro Wa), Lisu (Li Zu), Kachin, Karaung (Taron), and Burmese (Burman) ethnical groups intermingle. It is reasonable to extend the Hkakabo Razi National Park to the south (including all Naung Mung as far west as Putao) to further strengthen the efforts of the local authorities.

Acknowledgments

I thank all the authors and co-authors, M. Morrison, and the reviewers for the great support and fast implementation of all the contributions, as well as the presenters at the Portland meeting in August 2008. In particular, I thank J. H. Rappole, who dragged me the first time to Hkakabo Razi National Park in 2001. Many others need to be mentioned, including partners and helpers in the field at all places, technicians and curators in uncountable museums worldwide, and scientists involved in the general topic in publications, meetings, and workshops. Most of them are acknowledged in the other chapters, and I emphasize my thanks to them here. J. H. Rappole, J. P. Dumbacher, F. Woog, and P. J. J. Bates gave invaluable comments on earlier versions of the manuscript. Finally, I thank any whose contributions have inadvertently been overlooked. To download GIS shapefiles of Conservation International's "biodiversity hotspots," go to www.biodiversityhotspots.org/xp/Hotspots/resources/pages/maps.aspx. The abstract was translated into Myanmar by Ms. Hazel Khin Ma Ma Thwin.

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