生物多样性研究丛书

物种多样性研究与保护

Research and Conservation of Species Diversity

宋延龄　杨亲二　黄永青　主编

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内容提要

本书是我国第一本介绍物种多样性研究方法的专著。物种多样性研究与保护是当今生物多样性研究的核心内容之一。本书就这一热点，结合国内外该领域的最新成果，全面系统地介绍了物种多样性的研究与保护方法。书中所涉及的主要生物类群包括原核微生物、真菌、动物和植物。该书对于从事保护生物学、生物系统学以及生态学，特别是从事生物多样性保护与持续利用方面的研究人员、有关高等院校的师生以及自然保护工作者具有重要的参考价值。

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总 序

各种各样的生物资源是地球上人类赖以生存的基础。然而，由于人类活动的加剧，引起了全球环境的迅速恶化。最大限度地保护生物多样性已成为国际社会关注的热点。在1992年6月举行的联合国环境与发展大会上，包括中国在内的153个国家在《生物多样性公约》上签了字，从而使保护生物多样性成为世界范围内的联合行动。中国作为世界上生物多样性特别丰富的国家之一，不仅积极开展了生物多样性的保护活动，而且还最早制订了国家级生物多样性保护行动计划。

作为中国自然科学研究中心的中国科学院一直积极致力于生物多样性的研究工作。在国家科委、国家基金委等单位的支持下，经过四十多年的考察与研究，在许多课题和研究项目上取得了可喜的成绩，还先后组织编写了《中国植物志》、《中国动物志》、《中国孢子植物志》、《中国植被》、《中国高等植物图鉴》、《中国植物红皮书》(第一卷)等书，并增建和扩建了有关的研究设施如标本馆、植物园、定位研究站等，为中国生物多样性保护与持续利用提供了大量的资料和措施。为了加强生物多样性研究工作，在原生物多样性工作组的基础上，于1992年3月成立了中国科学院生物多样性委员会，统一协调生物多样性研究工作，并与国内外有关机构开展了各种形式的合作。

目前，中国科学院已有相当一批专家正在开展生物多样性方面的研究，从基因、物种、生态系统和景观四个水平上研究生物多样性的现状、受威胁或濒危的原因以

及保护与恢复的对策，并积极建设全国性的生物多样性信息系统，以期为中国的生物多样性保护与持续利用提供理论依据。

为了推动生物多样性研究工作，及时反映这方面的研究成果，促进跨世纪人才的培养，在继续编译《生物多样性译丛》的基础上，我们组织撰写了《生物多样性研究丛书》。这套丛书将集中介绍中国科学院生物多样性研究的最新成果和有关的基本原理与研究方法。由于生物多样性研究是综合性和实践性很强的新兴领域，编写这样的丛书也是我们的初步尝试，希望得到有关专家的积极支持，共同培育这棵刚刚破土而出的新苗。

许智宏

1996 年 9 月

序

在灿烂的星空中有一颗发出淡蓝色光芒的星球，她就是我们人类和其他各种生物的家园——地球。我们在这颗美丽的星球上生存繁衍，世世代代生生不息。

与地球上存在的许多生物种类相比，我们人类的历史很短暂。但是，人类是智慧生物，自在地球上出现的那一刻起，就开始去认知其生活的自然环境。由于动物、植物和微生物为人类提供了人类社会赖以生存和发展的物质基础，因此，认识和研究物种在人类认识自然界的历程中占据了重要的地位。分类学——一门记录、描述各种生物种类，研究物种的发生、发展与演化规律的科学，也就成为生物科学中历史最悠久的学科。

随着被记录和描述的物种的不断增加，人类痛苦地发现物种的灭绝事件不断发生，尤其是在人类进入工业化阶段以来，物种的灭绝速度已超出物种自然灭绝速度的几十倍、几百倍乃至几千倍，人类在研究造成物种超出正常速度灭绝的原因和机制的同时，也千方百计地采取各种措施来保护那些濒于灭绝的物种。人类在经历了错误之后终于认识到了其他生物物种对人类社会发展的重要作用，认识到其他生物种类也拥有在地球上生存的权利以及人类对其他生物种类负有的责任。今天，保护地球上的物种多样性已不仅仅是口号，而是变成了全世界人们的共识。

我国是世界上生物多样性最丰富的国家之一，因此，保护我国的物种多样性是我们义不容辞的责任。科学地认识我国物种多样性的现状是保护物种多样性的

良好开端，也是进一步保护我国生物多样性的基础。本书不仅介绍了我国科学家在物种多样性研究方面的贡献，而且还全面、系统地介绍了当今世界上在物种多样性研究领域中的新理论、新思想、新方法。参与本书编写的既有老一代的科学家，也有与人民共和国同龄的中年科学工作者，更有年轻一代的后来者。希望本书的出版能够实现作者们的愿望——为保护我国的物种多样性、保护世界的物种多样性、保护人类和其他生物物种共有的美丽家园，贡献一份微薄的力量。

王祖望

1997 年 5 月

前　言

物种是生物进化和分类的一个基本单位，是遗传多样性的载体和生态系统多样性的组成成分，因此物种是生物多样性最为明显的表现形式。物种多样性无疑应当是生物多样性研究的核心内容之一。事实上，生物学中发展最早而又极具生命力的分支学科——系统学(Systematics)，就是研究生物多样性并且主要是物种多样性的科学。系统学有其独立的研究思想和工作方法，同时又能不断广泛地吸收其他学科的成果，至今已发展为一门综合的学科。近年来，由于分支分类学(Cladistics)方法的广泛应用和分子系统学(Molecular systematics)的迅猛发展，特别是两者的有机结合和相互促进，使系统学研究进入了一个新时期。系统学的发展无疑会极大地增加我们对生物多样性特别是物种多样性的认识。

毋庸讳言，传统意义上的生物多样性研究，也即上述的系统学研究，在有意和无意之中几乎成为了一门“象牙之塔”中的科学。虽然系统学本身极具生命力，但由于长期与社会和经济背景相脱离，因此也难免活力日减而渐呈萎缩之势，研究经费和人才均愈趋匮乏。如果想到世界上大部分物种尚未得到记录和描述，而且有可能在未被记录和描述之前就已经灭绝，这种状况就不能不让人深感忧虑。所幸的是，国际上（也包括我国）的一些具有远见的生物学家近年来对生物多样性的概念重新进行了深入的阐释，赋予其以新的含义，将生物多样性的基础研究与生物多样性的保护紧密结合起来，使

社会各界和政府充分认识到生物多样性研究及保护与整个人类社会的生存和持续发展息息相关。由153个国家签字的《生物多样性公约》的成功颁布和实施已充分说明了这一点。在科学史上，像生物多样性研究那样如此广泛而深入地融入公众意识之中的科研思想和成果恐不多见。从这个意义上来说，目前国际上生物多样性的研究热潮不但是生物科学史上而且也是整个科学史上的一次盛举，其意义之深远决不可低估。作为生物多样性研究特别是物种多样性研究主力之一的系统学家，理应打破“象牙之塔”，迅速加入到生物多样性研究队伍中来，共襄盛举。

正是基于这种共识，我们邀请了活跃于我国动物学、植物学和微生物学界的生物系统学家和生物保护学家共同编写此书。他们研究的类群各不相同，研究深度和广度也不尽一致，但他们提出的研究思路和方法都朝着一个共同的目标——如何更深入地认识物种多样性和更有效地保护物种多样性。本书作为我国第一本物种多样性研究方法的专著，倘能起到抛砖引玉的作用，为推进我国的物种多样性研究贡献一点绵薄的力量，就不负我们编写的初衷了。

本书初稿完成以后，中国科学院动物研究所黄大卫、冯祚健、马勇，中国科学院植物研究所傅立国、马克平和中国科学院微生物研究所庄剑云、陈健斌诸先生分别对各章节进行了认真审阅，提出了许多宝贵的修改意见。中国科学院生物多样性委员会的侯淑琴女士也为本书的编写和出版付出了辛勤的劳动。本书的编写使得我国的动物学、植物学、微生物学工作者真正地走到一起，贡献出自己的学术思想和学术成果，这件事本身就非同寻常。在此，谨向以上单位和个人以及所有为本书的出版作出贡献的专家和朋友们致谢。

宋延龄　杨亲二　黄永青

1997年4月

Summary

The biological species on our planet comprise an interwoven linkage with the atmosphere, climate, soil, water, and other features essential for the existence of life. About 1.5 million species have been discovered and described by systematic biologists, which probably only accounts for less than 15% of the actual number. Millions of species remain unknown. Unfortunately, many species are in danger of extinction, and rapidly declining species diversity and disappearing habitats are documented worldwide. The diversity at species level will always need more attention for conservation than that at other levels, say, at genetic and ecosystem Levels, because the loss of species diversity is more obvious and quantifiable than the loss of genetic diversity and ecosystem diversity, and easy to be identified by human beings. This also explains why the value of species diversity in the conservation of biodiversity is most highly considered by biologists worldwide.

Species diversity surveys which have scientific meanings in China, one should say, have started since the early 1920's. From the data accumulated it is inferred that the biological species occurring in China account for more than 10% of the total species in the world. There are many species endemic to China, which have a high biological value to the world. Furthermore, new species were and are still continually discovered in China; for example, more than 500 species of insects and angiosperms had been added to the name lists from 1980 to 1986. Here, we should emphasize the fact that some areas in China have not as yet been intensively surveyed. Thus, more new species are expected to be found in China. Undoubtedly, the rich species diversity occurring in China is a invaluable part of the biological heritage of the world, and understanding it and protecting it are our duty.

In order to let our readers have a clear and overall picture on the present status of species diversity in our country, general reviews are contributed by some active Chinese systematists in chapters 2 to 12. They cover almost all major biological groups from prokaryotes, fungi, seed plants to mammals. Research methods used in these disciplines are introduced. Some chapters propose academic questions which should be addressed in the future, and conservation approaches for species diversity are also suggested. The essential points in each chapter may be summarized as follows.

The study of the biodiversity of prokaryotes is a main branch of microbiology. It deals with all prokaryote life forms, ecosystems, and ecological processes, and addresses the questions related to prokaryote diversity at genetic, species, and ecosystem levels. In chapter 2, Professor Liu Zhiheng introduces both traditional and modern methods for revealing the diversity of prokaryotes, including microbial nomenclature, numerical classification, chemical taxonomy, molecular taxonomy, and selective isolation from natural materials. All the

methods introduced here are essential for the establishment of a sound microbial taxonomy both for satisfying fundamental scientific needs and for designing effective isolation strategy.

For the purpose of improving the research of non-lichenized discomycetes in our country, Professor Zhuang Wenying reviews the history of non-lichenized discomycetes study in chapter 3. Important workers and their publications which have made great contributions to the development of non-lichenized discomycetes taxonomy are emphatically introduced. The non-lichenized discomycetes known in China account for about 13% of the current world records. The morphological features and criteria commonly used to distinguish species are provided. Methods and problems encountered when dealing with species diversity of discomycetes are discussed. Further efforts are needed to improve our knowledge since the current status is far from satisfactory in this field in China.

A lichen is a symbiotic association of a fungus and an alga or a cyanobacterium resulting in a stable self-supporting complex-thallus of specific structures and containing unique secondary metabolites, and its essence and scientific name are represented by the fungus. Lichens are also usually called lichenized fungi (or lichen-forming fungi). The number of known species is about 13 500 in the world and 1 800 in China. Lichenized fungi (through mutualism) have played and will play a vital role in the evolution of terrestrial life and the maintenance of biodiversity. Discussions are made on the position of lichenized fungi in biological evolution, research contents, taxonomy and systematics, flora and biogeography, the relationship between lichens and air pollution in chapter 4. In order to draw a whole picture for the readers of the field of lichenized fungi study, the author gives a brief review on the research history and methodology.

Fungi are the most important components of the soil microflora. Chapter 5 gives an introduction to the species diversity of soil fungi and their function in ecosystems. Methodologies used in the research of soil fungi and litter fungi are discussed, with emphasis on the methods of direct observation, isolation, and culture techniques.

Analyses on the current situation and historical background of the angiosperm biodiversity of China are made in chapter 6. High endemism is one of the major features of the Chinese flora of angiosperms, total 238 endemic genera having been found. The geographical distribution patterns of the angiosperms in the Chinese flora are complex and 6 areal-types and 19 subtypes are represented by families and 15 areal-types and 31 subtypes by genera. Among the angiosperms of China, about 4 000 species have been threatened to some degree, of which over 1 000 species are rare or seriously endangered. Reasons for endangerment of plant species are discussed here and suggestions for the biodiversity conservation of angiosperms in China are proposed.

Endemism is a very interesting and complex biogeographical phenomenon which attracts the attention of the biologists when they examine species distribution patterns. The study and precise interpretation of endemism will help us to better understand the origin of floras and their development processes. As known to all, endemic species have also significant value in the conservation of species diversity, therefore, a special chapter is written in this book to

discuss the problems of endemism in floras. In chapter 7, Professor Yang Qin'er gives a good review of the endemic phenomenon in the Chinese flora of seed plants. The concept and types of endemism and several hypotheses for interpretation of endemism are briefly introduced. He also proposes some approaches to address the questions on endemism. Discussion is mainly limited to the endemism at the species level, and local endemism represented by local endemics which have very restricted distribution ranges is the main object. Suggestions are made for the future study of the endemism in the Chinese flora at the end of the chapter.

Insects are the most species-rich of major animal groups. About 950 000 species of insects have been described from the world, and 45 000 species of insects have been described from China. The task of identifying and describing insect species is still huge, because it is estimated that the total number of insect species is between 2 000 000 and 30 000 000. Our knowledge of insect species diversity is very limited. People become more and more aware of the importance of understanding insect species diversity. Scientists around the world are actively studying the methodology for insect species diversity research. In chapter 8, some topics and advancs concerning insect species diversity studies are generally reviewed. Based on this review, the procedure for studying insect species diversity is proposed, which includes a series of study stages of surveying, analyzing and data processing. Guidelines and contents for each study stage, including a direction of reference sources, are proposed and given. General directives and priorities for studying insect species diversity are suggested.

Fish are a group among vertebrate animals that new species have been continually described every year because many rivers, lakes, streams, springs, and pools are poorly known. Considering the present status of study in fish diversity in China, chapter 9 is intended to introduce some basic knowledge and techniques in fish species diversity survey. The chapter begins with the present situation of species diversity of fish, and then methods and techniques of specimens collecting, treating and preserving of fish are introduced in detail. These methods and techniques came from practical experience, therefore, they are very effective and easy to practice. Since both fauna survey and classification are very important parts in the research of species diversity of fish, relevant research methods are separately introduced in Part four and Part five. Zoogeography is a discipline to study animal distribution throughout the space and time. The research methods of zoogeography and conservation biology of fish, such as Average Fauna Resemblance (AFR), Cluster Analysis, Parsimony Analysis of Endemicities (PAE) and Phylogenetic Analysis Using Parsimony (PAUP), are introduced in the last two paragraphs. Hopefully, readers will find chapter 9 is very helpful when they conduct a study on fish species diversity.

China harbours the richest bird species diversity in the world because its territory covers 2 zoogeographic realms, i. e., the Palaeoarctic and the Oriental. More than 100 bird species are endemic to China, which exhibit a significant value of avifauna of China. In chapter 10, keystone species and hot spots of bird species are analyzed. Hypotheses to explain why China owns the richest bird species diversity are presented. Based on the discussions on the reasons for the threats of bird diversity, suggestions on the bird conservation are proposed.

Raptors, including hawks, falcons and owls, are at the top position in bio-communities. They play an important role in maintaining ecological equilibrium. In China, total 86 species with 64 subspecies of raptors have been recorded. They belong to 2 orders, 4 families and 36 genera. All species of raptors in China are under protection. Chapter 11 reviews the results of research projects conducted in China on biology and ecology of raptors. Historically, raptors were distributed widely in ancient China. As early as in the Ming Dynasty, Li Shizhen (1596) had made a detailed record of raptors in his great book "Compendium of Materia Medica", which was considered the classic work concerning raptor diversity in China. His records were very close to the modern classification system of raptors. Five species with seven subspecies have been recorded in China for the first time since 1947. On the basis of local avifauna reported, South China Region is found to own the highest species diversity and richness in China. Few research programs have been conducted on the genetic diversity of raptors. Up to date, karyotypes of only 9 species of diurnal raptors and 4 species of owls have been reported briefly. Considering the components of the avifauna, there are slightly more species in the Oriental realm (26) than in the Palaeoarctic realm (16) among 88 species of raptors. Species of the Tytonidae are mainly distributed in the south areas of the Yangtze River. Shannon index as well as Simpson and Hurlber (PIE) index are introduced in this chapter to express the community diversity of raptors. The procedure of population abundance counting is also presented here.

More than 500 species of mammals have been recorded in China, accounting for 12.6% of the total mammal species in the world. The richness and endemism of Chinese mammal fauna are of important significance to the world. There are many mammals endemic to China, of which giant panda and Chinese river dolphin are the most famous. The present Chinese mammal fauna was formed from the late Tertiary period to the early Quaternary period. The orogenic movement of the Himalayas created the third pole in the world and provided a special environment for mammals. The fauna of mammals there has special components compared to other regions of China. Some researchers even proposed that the Himalayas might form a special zoogeographic realm from the result of their researches. Chapter 12 reviews the present status of mammal diversity, species distribution pattern, and analyzes the characteristics of Chinese mammal fauna. In the last part, the author introduces the research method of mammal species diversity.

Chapter 13 discusses the distribution trends of vertebrates in the world, and introduces the research methods in this field. Latitude, longitude, elevation, species-area effect, endemism, topography, climate, and habitat diversity are responsible for the distribution pattern of vertebrate animals in the world. Hypotheses proposed to explain that distribution trend by researchers worldwide and methods to study the problem of animal distribution trends are also introduced.

Species identification is a difficult and often frustrating task in biodiversity research. It is not easy even in taxonomic studies themselves when a species-rich group is concerned. Taxonomists have sought to overcome the difficulties of species identification by developing a

range of tools and techniques that have increasingly involved the use of computers. Of the recent developments in computer-aided species identification, multi-access keys, hypertext keys, expert systems and neural networks represent four main areas of great influence. Chapter 14 gives a brief introduction to each of the four different techniques and suggests which technique might be the most appropriate for a particular taxonomic group. The author strongly argues that expert systems of species identification should not be competitors but effective tools to taxonomists as well as non-taxonomic biologists.

Much meaningful and useful information about species diversity is carried by the specimens collected in taxonomic and systematic surveys and studies. In addition, specimen collection also provides us dynamic data, such as the changes of distribution ranges of species, population dynamics and habitat situation. Therefore, databases established on the specimen collection are considered very important by the international conservation organization and conservationists. Based on the discussions on the importance of species information system in the biodiversity research, Chapter 15 provides the process of data establishment step by step. The structure and flow chart of species information system are introduced. We believe that our readers will get some knowledge on database of species information system from this chapter and find this chapter is very helpful in their own work.

Habitat situation is closely related to the status of wildlife species in their natural distribution ranges. Habitat destruction and fragmentation have become a most serious threat to species of animals. Based on the understanding of the importance of habitats in the wildlife conservation, Dr. Li Diqiang makes a good review of habitat definition and historical development of knowledge on habitat theory in chapter 16. Habitat availability is not only dependent on the quantity, but also on the structure and quality. Habitat analysis will play a major role in species diversity conservation. Techniques and methods used in habitat measurement and analysis are introduced, and habitat evaluation methods are also proposed here.

Models of factors contributing to population viability are proving valuable in the species diversity conservation. The study of the way in which habitat loss, environmental uncertainty, demographic stochasticity, and genetic factors interact to determine extinction probabilities for individual species has been named population viability analysis, or PVA. Although PVA is a relatively new approach, it has been used to study many endangered species populations. Chapter 17 introduces a computer simulation program, Vortex models, which is used worldwide. The population viability analysis for the endangered species of eld's deer is being used as an example to demonstrate how to run the programs. Results using Vortex simulation program to analyze the population viabilities for panda, both in captive and wild populations, and for Chinese river dolphin, are illustrated. This chapter also discusses other utilization of Vortex model, such as making captive population management program in zoos, and returning captive animals to the wild.

As human disturbing activity to the natural environment becomes more and more serious, people become aware of the role of botanic gardens (including arboreta) and zoos in *ex situ* protection. In chapter 18, Professor Xu Zaifu reviews the contributions of botanic