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硕 士 学 位 论 文

陆栖脊椎动物多样性的地理格局及其决定因素

The geographical pattern and its determinants of terrestrial vertebrate diversity

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中 文 摘 要

生物多样性是可持续生物圈生态学的前沿领域，而生物多样性的大尺度格局是宏生态学(macroecology)和生物地理学(biogeography)研究中的核心问题。中国是世界上人口最多、人均资源占有量低的国家。因此，中国比其他国家更依赖于生物多样性。然而，巨大的人口压力、高速的经济发展对资源需求的日益增加和利用不当，使中国生物多样性受到极为严重的威胁，保护生物多样性已成为摆在人们面前的当务之急。所以，迄今为止，为了保护中国丰富的生物多样性，我国已经建立了大量的自然保护区。截至2007年底，中国已建立了2395个不同保护等级的自然保护区(不包括港、澳、台地区)(中华人民共和国环境保护部,2008)，评价和分析这些保护区的布局以及研究物种多样性的大尺度格局对于生物多样性的有效保护无疑是非常重要的。

本文选取进行过全面科学考察和物种编目的160处自然保护区，包括了中国几乎所有重要的陆地生态系统类型，基于搜集的资料而整合成陆栖脊椎动物的数据库，并利用气候、海拔、经纬度等环境信息，尝试分析：(1)中国陆栖脊椎动物主要类群物种丰富度的大尺度格局及其与环境因子的关系，探讨中国陆栖脊椎动物物种丰富度大尺度格局形成的主导因子。(2))中国陆栖脊椎动物β多样性的随空间距离的变化，以及β多样性的形成机制，即扩散过程和生态位过程的相对重要性。

中国有脊椎动物6347种，占世界种数近14%。其中，陆栖脊椎动物共有2761种，两栖类326种，爬行类410种，鸟类1336种，哺乳类689种。我们选取的保护区中两栖类有186种，爬行类有216种，鸟类有1050种，哺乳类有472种，分别占中国陆栖脊椎动物两栖类的57.06%，爬行类的52.68%，鸟类的78.59%，哺乳类的68.51%。通过地理信息系统(GIS)软件DIVA-GIS提取了主要的19个环境气候因子，利用R软件分析所有数据，由此得出以下结论：

1．保护区的两栖类和爬行类主要分布于长江流域以南，即包括四川省、湖北省、江西省在内的南方各省，而北方分布较少；鸟类和哺乳类在全国的分布范围要更加广泛，几乎遍及全国各省，但长江流域以及长江流域以南有着更明显的优势。保护区的各个类群的分布有着共有的热点地区，主要集中在横断山脉地区、华中地区和岭南地区。

2．保护区各类群的聚类分析结果显示，各类群的聚合方式充分体现了陆栖脊椎动物地理省的分布与地理环境密切相关的物种分化有着相互渗透的现象，但亦存在着明显的差异。而由物种累计曲线图的可以看出，当保护区数达到一定数目时，物种数增加的趋势逐渐变得缓慢而不明显，因此要增建扩建自然保护区，不能盲目而应使建立自然保护区的效益最大化。在不同的分类阶元上，陆栖脊椎动物各类群随着纬度的增加而各类群科属种的数目也随着增加；而经度方向上，四大类群都集中在中间部分，呈钟型分布，为二次方曲线相关。

3．在不同的分类级别上，各个类群具有一定的一致性，特别是各类群属的水平上存在明显的相关；而陆栖脊椎动物分类级别间，物种和高级分类阶元在数量上具强相关关系。

4．各类群与生态因子之间关系的分析结果显示，在合适的范围内，陆栖脊椎动物类群一般随着温度的增高而物种丰富度增高，且随着降雨量的增高丰富度也随之增高。根据环境-丰富度最优模型的筛选，两栖类筛选出的最佳模型总共有9项，包括月均温范围、最冷月最低温、最冷季均温、年降水量、降水的季节性、最暖季降水量、最冷季降水量、海拔和面积；爬行类筛选出的最佳模型总共有5项，包括最干季均温、最冷季均温、最干月降水量、最冷季降水量和面积；鸟类筛选出的最佳模型总共有5项，包括年均温、温度季节性、最干季均温、最冷季均温和最湿季降水量；哺乳类筛选出的最佳模型总共有10项，包括年均温、月均温范围、等温性、最暖月最高温、最干季均温、年降水量、降水的季节性、最干季降水量、海拔和面积。其中，两栖类主要的影响因素为月均温范围、最冷月最低温和最冷季均温；爬行类的主要影响因素为最干季均温、最冷季均温和最干月降水量；鸟类的主要影响因素为年均温、最干季均温和最冷季均温；哺乳类的主要影响因素为年均温、月均温范围和最暖月最高温。由此说明温度和水分是决定中国陆栖脊椎动物物种丰富度格局的主要环境因子，这与前人的研究是一致的。

5．中国东部陆栖脊椎动物的β多样性以两栖动物和爬行动物最高，其次是鸟类和哺乳类，β多样性与物种类群的扩散能力呈负相关。对于陆栖脊椎动物而言，环境因子对其β多样性的形成更为重要，即生态位限制大于扩散限制，但优势不够明显，而环境因子和地理距离的双重交互作用对β多样性的形成则影响甚大。

关键词：陆栖脊椎动物；物种丰富度；地理格局；β多样性

Abstract

Biodiversity is a front edge field in sustainable biosphere ecology,and the large scale pattern of biodiversity is the core for research in macroecology and biogeography.China has the biggest population but very low per-capita quantity of the resources.Therefore,China depends more than other countries on biodiversity.However,due to big population,increasing demand and unreasonable use of resources for rapid economic development,biodiversity in China has been severely threatened.Protecting biodiversity becomes our first imperative.So we have built up quite a lot nature reserves till now.By the end of 2007,Chinese mainland has 2395 nature reserves of different protection level(Ministry of Environmental Protection of the People's Republic of China,2008).So it is of great significance to evaluate and analyze the layout of these nature reserves and protective effects on biodiversity that the large scale pattern of biodiversity brought.

We selected 160 nature reserves that have experienced overall scientific investigation and been made into species catalogue,including nearly all significant terrestrial ecosystem in China.According to the data which were collected and integrated we had obtained terrestrial vertebrates database,basing on environment information,i.e.climate,altitude,longitude and latitude etc,this article tried to analyze the following aspects: (1) species diversity at large scale in major taxa of terrestrial vertebrates in China and its relationship with environmental factors,and discuss key formative factors of species diversity at large scale; (2) the change of β diversity in China's terrestrial vertebrates with space and distance,as well as the formation mechanism of β diversity,that is the relative importance between niche restriction and diffusional limitation.

China has 6347 species of vertebrates,accounting for nearly 14% of the world's species.Among them,terrestrial vertebrates have a total number of 2761,what the specific ratio is,amphibians have 326,reptiles have 410,birds have 1336,and mammals

have 689.The protected areas of we selected have 186 species of amphibians,216 species of reptiles,1050 species of birds,and 472 species of mammals,which are accounting for 57.06% of amphibians,52.68% of reptiles,78.59% of birds,and 68.51% of mammals .Through the geographic information system (GIS),DIVA-GIS extracted the 19 environmental climatic factors.From analysising all data using R software,the main conclusions are as following:

1.Amphibians and reptiles of protected areas mainly distributed south of the Yangtze River basin,which included the South to involve Sichuan,Hubei and Jiangxi provinces,while the northern part distributed less;birds and mammals of the country were more widespread distribution,almost throughout all provinces of the country,but south of the Yangtze River and the Yangtze River basin had more significant advantages.A total distribution of each taxa in nature reserves had hot spots in common,mainly in cross-sectional mountains,central China and the Lingnan region.

2.The cluster analysis result of groups in nature reserves indicated that cluster mode of each group fully demonstrated the interaction as well as obvious difference between geographic distribution of terrestrial vertebrates and species splits which was closely related to the geographical environment.Species accumulation curve showed that when the number of nature reserves was big enough the increase in species would slow down,even inconspicuous to tell;therefore increasing and expanding nature reserves were necessary,and we should maximize their benefits,avoiding blind investment.In different taxonomic categories,the number of family,genus and species of terrestrial vertebrates increased with latitude increasing.Along longitude,the patterns of species richness for each group were hamp-shaped,which were quadratic curved correlation.

3.On a certain taxonomic rank,certain uniformity existed in each taxa,especially genus was obviously correlated on the level.While in different taxonomic ranks of terrestrial vertebrates,species and higher taxonomic category had strong correlation in quantity.

4.In a appropriate range,species richness of terrestrial vertebrate taxa generally increased with temperature and rainfall increasing.The selected best models of amphibian based on AIC including 9 variables about Mean Monthly Temperature Range,Min Temperature of Coldest Month,Mean Temperature of Coldest Quarter,Annual Precipitation,Precipitation Seasonality,Precipitation of Warmest Quarter,Precipitation of Coldest Quarter,elevation and area; The selected best models of reptile based on AIC including 5 variables about Mean Temperature of Driest Quarter,Mean Temperature of Coldest Quarter,Precipitation of Driest Month,Precipitation of Coldest Quarter and area; The selected best models of bird based on AIC including 5 variables about Annual Mean Temperature,Temperture Seasonnality,Mean Temperature of Driest Quarter,Mean Temperature of Coldest Quarter and Precipitation of Wettest Quarter.The selected best models of mammal based on AIC including 10 variables about Annual Mean Temperature,Mean Monthly Temperature Range,Isothermality,Max Temperature of Warmest Month,Mean Temperature of Driest Quarter,Annual Precipitation,Precipitation Seasonality,Precipitation of Driest Quarter,elevation and area.The main factors of amphibian among these were Mean Monthly Temperature Range,Min Temperature of Coldest Month and Mean Temperature of Coldest Quarter; the main factors of reptile were Mean Temperature of Driest Quarter,Mean Temperature of Coldest Quarter and Precipitation of Driest Month; the main factors of bird were Annual Mean Temperature,Mean Temperature of Driest Quarter and Mean Temperature of Coldest Quarter; the main factors of mammal were Annual Mean Temperature,Mean Monthly Temperature Range and Max Temperature of Warmest Month.It showed that temperature and moisture were the main environmental factors to determine species richness patterns of Chinese terrestrial vertebrate,which was consistent with previous studies.

5. β diversity of vertebrates in Eastern China can be ranked as amphibians and reptiles in the highest,followed by birds and mammals.This indicated a negative relationship between β diversity and dispersal ability of each taxa.For terrestrial vertebrates,the

environmental factors on the formation of β diversity were more important,which niche restriction was greater than diffusional limitation,but the dominant position was not in evidence.The double interaction of environmental factors and geographic distance had greater impact on formation of β diversity.

Key Words: terrestrial vertebrate; species richness; geographical pattern; β diversity

目 录

Contents

第一章 前言

1.1 生物多样性概念及研究进展

1.1.1 生物多样性概念

生物多样性(biodiversity)一词，最初是由Fisher和Williams(l943)在研究昆虫物种—多度关系时提出的，但生物多样性这一术语及其内涵在全球范围内被人们如此广泛的理解和接受还是80年代后期的事(钱迎倩,1995)，特别是在1992年环境与发展大会上《生物多样性公约》的正式签署(钱迎倩等,1994;杨利民等,1997)。目前人们公认的生物多样性是指生物及其与环境形成的生态复合体以及与此相关的各种生态过程的总和，包括数以百万计的动物、植物、微生物和它们所拥有的基因以及它们与其生存环境形成的复杂的生态系统，是生命系统的基本特征(马克平等,1994)。

生物多样性是一个内涵十分广泛的概念，包括多个层次或水平。其中研究较多、意义重大的主要有遗传(基因)多样性、物种多样性、生态系统多样性这三个“经典”层次和景观多样性第四个层次(马克平,1993)，对此已形成基本一致的看法，并给予了明确的解释(马克平,1994;陈灵芝,1994;张金屯,1999;蔡晓明,2000)，目前，大多数学者都倾向于这样的划分。

生物多样性测定主要有三个空间尺度：α多样性，β多样性，γ多样性。α多样性主要关注局域均匀生境下的物种数目，因此也被称为生境内的多样性(within-habitat diversity)。β多样性可以定义为沿着环境梯度的变化物种替代的程度(Whittaker,1972)，亦有人称为物种周转速率(species turnover rate)、物种替代速率(species replacement rate)和生物变化速率(rate of biotic change)(Pielou,1975)，β多样性还包括不同群落间物种组成的差异，不同群落或某种环境梯度上不同点之间的共有种越少，β多样性越大(Magurran,1988)。控制β多样性的主要生态因子有土壤、地貌及干扰等。γ多样性描述区域或大陆尺度的多样性，是指区域或大陆尺度的物种数量，也被称为区域多样性(regional diversity)。控制γ多样性的生态过程主要为水热动态、气候和物种形成及演化的历史(马克平,1993)。

在物种多样性层次上，主要包含物种丰富度和β多样性。物种丰富度是指一定大小的样方中的物种数目，不考虑种间个体数量也可以用生物量、盖度等表示