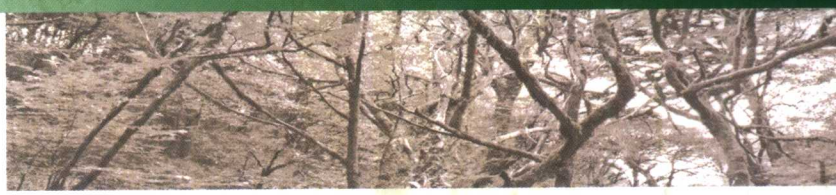
濒危植物元宝山冷杉与南方红豆杉种群生态学研究



李先琨 等 著

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内 容 简 介

本书系统介绍了元宝山林区的环境特点和植物多样性，重点针对濒危植物——元宝山冷杉群落及种群特征、南方红豆杉群落与种群特征、南方红豆杉无性系种群克隆生长等进行论述，旨在为元宝山冷杉和南方红豆杉的保护和有效开发提供科学依据和生态学理论基础。本书内容是作者十多年来调查研究成果的总结，具有丰富的第一手资料，研究方法有所创新，在裸子植物的研究中具有原始创新性。

本书可以作为高等院校和科研院所植物学、生态学、林学及相关专业研究生参考教材，也可以作为植物学、分子生物学、生态学科研工作者的参考资料。

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本书著作者

李先琨　广西植物研究所（广西，桂林市 541006）
向悟生　广西植物研究所（广西，桂林市 541006）
欧祖兰　广西植物研究所（广西，桂林市 541006）
苏宗明　广西植物研究所（广西，桂林市 541006）
黄玉清　广西植物研究所（广西，桂林市 541006）
唐润琴　广西植物研究所（广西，桂林市 541006）
宁世江　广西植物研究所（广西，桂林市 541006）
陆树华　广西植物研究所（广西，桂林市 541006）
何成新　广西植物研究所（广西，桂林市 541006）
李瑞棠　广西植物研究所（广西，桂林市 541006）
唐绍清　广西师范大学　（广西，桂林市 541004）
李凤英　广西师范大学　（广西，桂林市 541004）
王　燕　广西师范大学　（广西，桂林市 541004）
莫权辉　广西植物研究所（广西，桂林市 541006）
赵天林　广西植物研究所（广西，桂林市 541006）
叶文培　广西植物研究所（广西，桂林市 541006）

序

首先祝贺李先琨和苏宗明先生等人的专著《濒危植物元宝山冷杉与南方红豆杉种群生态学研究》正式出版了。在出版之际，苏先生希望我写几句话作为序言。作为晚辈，我实在不敢当。但想到我1998年去广西调查水青冈群落时，苏先生及广西植物研究所的不少前辈和同仁所给予的热心指教和无私帮助，又让我觉得不得不从命。所以，写上这段文字，算不上序言，权当我个人的一点感想。

我国是世界上生物多样性最为丰富的国家之一，在世界保护联盟评定的12个“巨大生物多样性国家”（mega-diversity countries）中，中国名列第八。广西对中国这样一个生物多样性的大国地位有着巨大的贡献。据记载，广西有野生维管束植物8354种，其中有国家一级保护植物40种，二级保护植物69种；珍稀濒危植物87种；兰科植物300多种。但如同我国的许多地区一样，由于受人类生产活动的影响，广西的生物多样性也遭受了严重的破坏。根据1998～2000年对广西境内89种重点保护野生植物的调查，发现有42种植物的分布范围及数量在萎缩，有些可能已经灭绝。例如，国家一级保护植物、分布于广西和湖南交界的资源冷杉，是在20世纪70年代发现的，当时广西境内保存有高20～28m，胸径30～60cm的大树2500株以上。但历经了26年后（2004年），残存的个体仅有96株，并且在这些残存的个体中，大树已荡然无存，最高的植株仅为12.5m，最大胸径19.7cm。

为了保护这些日趋濒危的物种，广西植物研究所的李先琨先生、苏宗明先生及广大同仁以科学工作者的强烈责任感，开展了大量卓有成效的工作。本书报道的元宝山冷杉与南方红豆杉种群生态学的研究便是他们的重要成果之一。

元宝山冷杉和南方红豆杉都是我国一级保护植物。元宝山冷杉是元宝山林区特有树种，在1998年国际自然保护联盟（IUCN）拟定的“针叶树行动计划”中被列为全球重点保护的针叶树种；南方红豆杉是提取高效抗癌药物紫杉醇的原料，元宝山林区海拔1800m以上的地区是其分布较为集中的地方。元宝山位于广西北部融水苗族自治县境内，是广西一座很重要的山体。我本人曾于1998年夏天去过那里进行过水青冈群落的调查。这里植物区系起源古老，成分复杂，特有种多，珍稀濒危植物和古老孑遗物种不少。海拔1200m以上的中山常绿落叶阔叶混交林和针阔叶混交林，是一片名副其实的原始森林，林木高大，林内荫湿，树干布满苔藓，其原始性之强、古老性之明显，不但在广西境内不可多得，国内其他地区也属少有。自1992年以来，广西植物研究所的李先琨先生、苏宗明先生等八上元宝山，对以元宝山冷杉和以南方红豆杉为优势的群落进行了深入的研究。《濒危植物元宝山冷杉与南方红豆杉种群生态学研究》一书呈现给我们的就是在这种原始生境下，元宝山冷杉和南方红豆杉种群生态学特性的真实面貌。

本书内容丰富、全面，从群落的区系组成、结构、外貌和物种多样性，到种群数量、结构、动态以及繁殖特性与遗传多样性等，深入地探讨了这两种濒危植物的群落生态学和种群生态学特征，不仅丰富了植物种群生态学理论，也为开展对它们的保护提供

了科学依据。

此书在理论上有不少重要创新。如他们发现，在元宝山原始古老的植物群落中，南方红豆杉具有克隆植物生长的特性，并且主要以这种方式延续种群。这是一个非常重要的发现，因为过去对克隆植物生长的研究，多以苔藓、草本为主要对象，有关木本植物，尤其是裸子植物克隆生长的研究则几无报道。这个发现对南方红豆杉种群的恢复和保护无疑也是一个福音。

我十分欣赏和敬佩广西植物研究所的前辈和同仁们脚踏实地、努力奉献的忘我精神：他们长年工作在生活条件十分艰苦的山区，为中国生态学的发展和生物多样性的保护默默无闻地工作着。在《濒危植物元宝山冷杉与南方红豆杉种群生态学研究》一书出版之际，我祝贺他们，但我更要感谢他们，是他们的奉献才使得很多像元宝山冷杉与南方红豆杉这样的珍稀濒危物种在我国得以保存，得以延续。

中国科学院院士　方精云

2006年6月于北京大学

前　言

元宝山林区位于广西北部的融水苗族自治县境内，北纬 25°22′～25°32′、东经 109°07′～109°13′的范围内，面积 39km^2。主峰蓝坪峰海拔 2081m，最高峰无名峰海拔 2086m，为广西第三高峰。山体切割深度一般大于 500m，最大为元宝峰，达 1600m。元宝山自元古代就出露于海面成为陆地，为广西起源最古老的山体。

元宝山林区可以说是广西壮族自治区目前原生植被保存最好的地区，海拔 1200m 以上的森林植被保存相当完整。现存的中山常绿落叶阔叶混交林不仅面积大，而且群落的原生性状也很强。海拔 1400m 以上连续大面积（约 1500hm^2）地保存着的以亮叶水青冈为主，包括光叶石栎、包果石栎、贵州石栎和黔桐在内的常绿落叶阔叶混交林，其林相之完整、发育之典型、原始性状之强、古老性之明显，不但在广西境内不可多得，国内其他地区也属少有。除了大面积连续的中山常绿落叶阔叶混交林外，海拔 1200～2050m 的垂直地段内还保存着以广东松、元宝山冷杉、南方铁杉、南方红豆杉等为主的中山针阔叶混交林，也同样是广西最古老、最原始的森林。本区植被的特有现象相当突出，属于广西或我国特有的植被类型较多。针叶林类型中，既有全世界仅产于此地的元宝山冷杉林，又有我国华南、西南山地特有的广东松林、福建柏林、南方红豆杉林和南方铁杉林等。阔叶林类型中，有广西或华南山地特有的长柄水青冈林、亮叶水青冈林、白辛树林、马尾树林、红岩杜鹃林、猫儿杜鹃林、少果杜鹃林和矮黄杨林等。所有这些类型都是我国生物多样性的关键类群。

元宝山冷杉是松科冷杉属的常绿针叶乔木，它是继 1976 年吴鸣翔在浙江发现百山祖冷杉之后的又一重大发现。元宝山冷杉是世界上仅产于广西融水苗族自治县元宝山的孑遗、濒危植物，是研究我国第四纪冰川时期植物区系和气候变迁的“活化石”，也是我国生物多样性的关键类群。在国家公布的首批珍稀濒危保护植物中，它被列为一级保护的濒危植物，并于 1998 年被 IUCN“针叶树保护行动计划”列为重点保护对象。元宝山冷杉不但属于高度濒危、亟待保护的植物类群，而且属于具有重大科学研究价值的类群。元宝山冷杉是第四纪冰期幸存下来的濒危植物，是我国大陆冷杉属植物纬度分布最南、海拔分布较低的种类，它的发现对于研究古气候及古生物区系有重要意义，是研究气候变化和植物变迁的依据。元宝山冷杉分布范围狭窄，集中分布在元宝山林区海拔 1900～2000m 的蓝坪峰，老虎口、白雪岭、燕子坳等地也有零星分布。它生长于针阔叶混交林中，面积仅 20hm^2 左右，在其他的地方只有零星分布，种群数量不足 1000 株。元宝山冷杉自然更新能力差、结实周期长（二三年结一次果）、结实量少，且具有大小年之分，目前种群处于极度濒危状态。对元宝山冷杉种群的保护生物学研究，国内有少数科研人员做过一些初步的调查研究工作，国外尚无人涉足。元宝山冷杉种群不仅亟需有效保护，更需要采取一定的技术措施促进种群的延续与发展。由于自然生境严酷，数量极度稀少，种群的生存与发展难以保证，天然条件下更新繁殖率低，因而加强元宝山冷杉繁殖技术的研究，提供一定数量的种苗以延续其种群显得非常迫切。研究成

果的缺乏也是元宝山冷杉种群有效保护的障碍。

当前，无性系植物克隆生长的研究成为世界植物生态学研究中的一个新热点，克隆生长的空间分布格局是无性系植物适应环境和分株之间相互作用的结果。克隆植物具备许多优点，是植物种群生态学研究的典型实验材料。由于克隆植物生长与能量分配、生态对策、遗传多样性等进化生态学热点问题密切相关，因而对克隆植物生长的研究异常活跃，国际重要学术刊物的有关文献数量呈上升趋势。克隆植物突破了传统的植物个体“固定着生”的观念，与其他克隆植物生态学研究结果一起丰富了主要在研究非克隆植物基础上（尤其是关于个体及个体以上组织水平）建立的生物学和生态学理论。目前对克隆植物生长的研究，多以苔藓、草本为主要对象，有关木本植物尤其是乔木植物的研究少有报道，而有关大型裸子植物克隆生长的研究尚属空白。南方红豆杉是红豆杉科红豆杉属植物，是抗癌药物紫杉醇（Taxol）的资源植物。由于紫杉醇应用范围广、需求量大，因而药源短缺成为当前主要矛盾，致使南方红豆杉野生资源破坏相当严重、日趋濒危。元宝山林区保存有较完整的南方红豆杉林，通过多次的野外调查分析，我们认为元宝山的南方红豆杉主要以无性繁殖方式延续其种群，其萌芽力强、繁殖成活率高、易适应环境，具有克隆整合的过程，能较好地维持种群数量并实现世代交替。研究南方红豆杉无性系种群的克隆生长，探索种群克隆生长行为、种群更新的方式和延续途径，将为珍贵植物资源的保护提供可靠的理论保证，同时，也将在理论领域推动克隆植物生态学的发展，丰富生物学和生态学理论；对国际学科前沿的探索也具有积极的作用。

广西植物研究所的科技工作者从20世纪80年代开始对元宝山林区进行了多次深入调查，既有多学科的自然科学考察，也有针对珍稀濒危植物开展的专项调查，取得了多项成果。本书作者从1992年开始对元宝山冷杉进行资源调查，多次得到广西自然科学基金（9518011、9811013、0007008）、国家自然科学基金（39960018）的资助，前后8次组织科技人员进入林区对元宝山冷杉种群、南方红豆杉种群开展调查研究工作，克服了常人难以想像的困难，获取了大量的第一手资料，本书就是对我们近年调查研究工作的全面总结。

本研究成果为保护和开发元宝山冷杉及南方红豆杉植物资源提供了理论依据，具有较大应用潜力，丰富了保护生物学和植物生态学内容，具有重要科学意义。经国内外9名知名生态学家组成的鉴定委员会评审，认为本研究成果具有原始创新性，整体上达到国际先进水平。鉴定专家对研究报告的编写提出了建设性意见，我们根据有关意见进行了补充实验，完善了有关内容。

本研究成果的取得和本专著的出版，得到广西壮族自治区科技厅、林业局的支持，以及广西融水苗族自治县林业局和元宝山自然保护区管理处的大力协助，没有他们的配合和无私的帮助，我们的野外调查和监测工作不可能顺利进行。

中国科学院植物研究所首席研究员董鸣博士对本书的撰写给予无私的帮助；科学出版社对本书的出版给予大力支持和帮助，特别感谢责任编辑为拙作付梓不辞辛劳；国家自然科学基金委员会主任陈宜瑜院士对本书的出版表示关注和支持，方精云院士在百忙之中为本书作序，值此专著出版之际，衷心感谢所有为本书出版付出劳动的人们。

本书涉及内容较为广泛，但由于客观条件的限制，加之作者水平有限，不妥之处在所难免，敬请同行专家和广大读者不吝赐教！

李先琨

2005年11月

Summary

Yuanbaoshan (National Park) forest in the Miao Minority Autonomous County of northern Guangxi Zhuang Autonomous Region, China (109°07′～109°13′E, 25°22′～25°32′N), occupies 39 km^2. The highest point, an peak in the Yuanbaoshan range, rises 2086 m ASL, while the best known peak, Lanping Peak, is 2081 m ASL. This third highest mountain range in Guangxi displays the most intact forest in all of Guangxi, with many Tertiary relict species. Yuanbaoshan's climate is mid-subtropical humid, with a significant altitudinal temperature and humidity gradient. Red soils are typical but the soil types vary distinctly with altitude, and they include mountain red soil, mountain red-yellow soil, yellow-brown soil, and mountain meadow soil. Yuanbaoshan forest is considered the best protected primary woodland in Guangxi; The forest is fully preserved at altitudes higher than 1200 m, with a large continuous area of mixed mid-mountain evergreen and deciduous broadleaved forest, and mixed mid-mountain conifer and broad-leaf forest, in each case exemplifying unique properties. The typical, yet rare, primary mixed evergreen and deciduous forests cover over 1500 ha at an altitude of over 1400 m. The succession of the forest developed very well and with all forms which the subtropical forest or vertical zonation might have. Besides evergreen broad-leaved forest, the area between 1200 m to 2050 m ASL is also distributed with broad-leaved and coniferous mixed forest dominated by *Abies yuanbaoshanensis*, *Taxus chinensis* var. *mairei* and *Tsuga chinensis*, *Pinus kwangtungensis*, and so on in mixed mid-mountain conifer and broadleaved forest, showing it is most intact forest in all of Guangxi. The forest consists of several species of Guangxi and Chinese endemic vegetation. In the conifer forest, for instance, there is an *Abies yuanbaoshanensis* community, which is only found here in the entire world; and communities of *Pinus kwangtungensis*, *Fokienia hodginsii*, *Podocarpus brevifolius*, *Taxus chinensis* var. *mairei* and *Tsuga chinensis* whose dominant species are endemic to the southern China mountainous region. Furthermore, when considering broadleaved forest, the communities of *Fagus longipetiolata*, *Fagus lucida*, *Pterostyrax psilophyllus*, *Liriodendron chinense*, *Rhoiptelea chilantha*, *Rhododendron haofui*, *Rhododendron cavaleriei*, *Rhododendron maoerense*, *Rhododendron oligocarpum*, *Buxus sinica* etc., are all endemic to Guangxi, and thus also to southeastern China only. All of these vegetation forms are considered as the "keystone" of Chinese biodiversity.

Abies yuanbaoshanensis, in the Pinaceae, is distributed at lower altitudes than other species of *Abies* in China, and it is the most southerly distributed in Northern Hemisphere. It is listed in the *China Plant Red Data Book* as class I, and is an IUCN protec-

ted key species. Its stenotopic species center is an area of about 20 ha, at 1900～2000m on the Lanping Peak of Yuanbaoshan Mountain, with less than 1000 individual plants experiencing very severe conditions. *Abies yuanbaoshanensis* community, therefore, is clearly a key biodiversity group in China.

At its highest concentration: *Taxus chinensis* var. *mairei* is distributed within the mixed forest above 1900m, second, in a central area at over 1600 m around Lanping Peak, and, third, concentrated at altitudes of over 1300m in Yuanbaoshan Mountain. Our field investigations and analysis found that *Taxus chinensis* var. *mairei* generates its population clonally, with a fine sprout capability, showing high reproduction and survival, and an ease of environmental adaptation. This species can process the clonal integration in order to maintain population scale and, as well, to accomplish alternation of generations. By studying *Taxus chinensis* var. *mairei*, clonal population growth behavior has been discovered, as well as its reproduction and extension of its population. This discovery will provide methodology and theory for protecting this resource and will promote the study of clonal species populations generally, and thus enhance the theory of both its biological and ecological development. Coniferous and broad-leaf mixed forest are essential forms in the Yuanbaoshan Mountain Belt. Conifer species, such as *Tsuga chinensis* and *Abies yuanbaoshanensis*, and broadleaved species, *Acer maximowiczii*, *Manglietia chingii*, *Symplocos paniculata*, *Acanthopanax evodiaefolius* var. *gracilis* and *Cyclobalanopsis glauca* dominate the main tree canopy, while *Taxus chinensis* var. *mairei*, the most important species in the community, dominates the mid and lower layers accompanied usually by the evergreen species, *Litsea pedunculata* and *Rhododendron haofui*. Yet *Fargesia nitida* is an absolute dominant species in shrub layer, accompanied by saplings of arborous species. The microclimate within these communities is shady and humid, fostering the growth of *Ophiopogon* spp., Liliaceae and a rich layer of mosses and lichens.

Similarly, evergreen and deciduous mixed forests are the best protected vegetation forms in Yuanbaoshan. The deciduous species, *Fagus longipetiolata*, *Fagus lucida*, *Pterostyrax psilophyllus*, *Acer maximowiczii*, and *Nyssa sinensis*, and the evergreen species, *Schima argentea*, *Castanopsis eyrei*, *Cyclobalanopsis oxyodon* and *Manglietia chingii*, dominate the crown layer; while *Sterwardia gemmata* and *Symplocos paniculata* rule the mid and lower layer. *Lithocarpus naiadarum* and *Rhododendron haofui* are the main species of evergreens. In this forest, communities can be dominated by deciduous species, (e. g. *Fagus lucida-Acer maximowiczii-Sterwardia gemmata*), or by evergreens (e. g. *Fagus lucida-Illicium majus*, *Schima argentea-Nyssa sinensis*). The shrub layers can be composed of densely dominant *Fargesia nitida*, or of sparse seedlings and saplings of crown species. Usually, there is little grass layer, but rather the ferns or *Ophiopogon* spp. dominate the ground layer of vegetation.

We have recorded 107 plant species in the *Abies yuanbaoshanensis* community, in 81

genera, 52 families. Of these 10 genera in 8 families are ferns, 4 genera in 3 families are gymnosperms, 58 genera in 36 families are angiosperms, and 9 genera in 5 families are monocotyledonous. The most frequent family is Rosaceae (9 species), followed by ① Ericaceae and Liliaceae (6 species each); ②Caprifoliaceae and Araliaceae (4 species each); ③Lauraceae, Berberidaceae, Theaceae, Fagaceae, Aquifoliacae, Celastraceae, Rutaceae, Syplocaceae and Gesneriaceae (3 species each). There are 13 other families with 2 species each, and 25 families with 1 species each. There are 36 arborous species (4 conifers and 32 broadleaved), which consist of 25 evergreen species (all the conifers are evergreen species) and 11 deciduous species.

Commonly, *Litsea pedunculata*, *Taxus chinensis* var. *mairei*, *Tsuga chinensis* are the main companion species in the *Abies yuanbaoshanensis* communities, where underneath, there are 23 shrub species (12 evergreen and 11 deciduous) and *Fargesia nitida* is frequently dominant; and there are 29 species in the herbaceous layer including 6 ferns, 12 angiosperms and 11 monocotyledons. Habitually *Ophiopogon* spp. dominate of which *Ophiopogon bockianus* var. *angustifoliatus* has the largest coverage. Epiphyte and liana species (8 of each), and mosses share an interlayer. Although there are only 107 species found in *A. yuanbaoshanensis* community, with an average of 22 species in each sample plot ($600m^2$), indicating uncomplicated species composition in the vegetation; however, the genera and families of oligotrophic species usually form a high proportion of the total. The floristic composition of the crown layer is stable with subtropical species predominating; and the community is mainly composed by evergreen broadleaved phanerophyte species with unifoliate, waxy leaves, and microphyllous leaves. Thereby, this community shows differences in its vertical zonation from both subtropical and warm temperate forests.

The niche breadth of the main species of the *Abies yuanbaoshanensis* communities has a range of: *Acer maximowiczii*, *Abies yuanbaoshanensis*, *Taxus chinensis* var. *mairei*, *Illicium majus*, *Litsea pedunculata*, *Cyclobalanopsis glauca*, *Manglietia chingii*, *Tsuga chinensis*, *Rododendron haofui*, *Clethra kaipoensis*, *Acanthopanax evodiaefolius* var. *gracilis*, *Pieris formosa*, *Rhododendron* spp., *Camellia caudata*, *Eurya loquiana*, *Enkianthus chinensis*, *Taxus chinensis* var. *mairei* and *Tsuga chinensis*, are usually the only two species to overlap with *Abies yuanbaoshanensis*, indicating that the competition between *A. yuanbaoshanensis* and other species is relatively mild, and demonstrating that the community is stable. Interspecies associative index presents a significantly positive correlation between the major populations as a whole. Analysis of 105 species-species pairs using association indices found that, although 96 pairs are insignificant, positive significant correlations exist between the major species. In *A. yuanbaoshanensis* communities, intraspecific competition is much more intensive than that between it and other species. Thus self-thinning influences the dynamics of the *A. yuanbaoshanensis* population more than allo-thinning. In trees of more than 7.5cm DBH

the bigger the tree diameter, the less competition is exercised by neighbouring trees within an 8m radius. To regress the tree diameter of *A. yuanbaoshanensis* with the competition index between *A. yuanbaoshanensis* and its neighboring trees, it is shown an exponential relationship.

With respect to the *Taxus chinensis* var. *mairei* communities, a floristic analysis similar to that used for *A. yuanbaoshanensis* reveals its geographically simple floral composition, and also that the genera and families with oligotrophic species range occur in relatively high proportion. The floristic composition of the crown layer is stable with subtropical properties dominant. The physiognomy of the *T. chinensis* var. *mairei* community appears regularly as wax, unifoliate, microphyll forms of evergreen broadleaved phanerophyte, demonstrating vertical zonation. An insignificant relation between most partners demonstrates an independence of interspecies. This "laxity" outcome maybe associated with the mature stage of community development. As few of major populations show negative correlations, there is no positive correlation, and populations spread individually, this may be a token of the mature successional stage of the community. The diversity index of *T. chinensis* var. *mairei* of the study site is similar to that of typical subtropical latitude and altitude zonal sites, confirming that it is a well-preserved and mature climax community.

In a complete survey, the population of *Abies yuanbaoshanensis* was divided into 7 life-history classes: Ⅰ. Seedling Class 1 (S1), H<50cm; Ⅱ. Seedling Class 2 (S2), H: 50～100cm; Ⅲ. sapling (S3), H≥100cm, DBH<3.0cm; Ⅳ. arboret (S4), 20.0>DBH≥3.0cm ; Ⅴ. mid-age trees (S5), 35.0>DBH≥20.0cm ; Ⅵ. adult (S6), 50.0>DBH≥35.0cm; Ⅶ. big trees (S7), DBH≥50.0cm. The number of living plants of *A. yuanbaoshanensis* population was less than 1000 with only about 100 plus adult and big trees, and many more seedlings than larger class members. Only 31 plants of DBH≥20cm were found and the biggest plant was 74cm DBH.

The dynamic of *A. yuanbaoshanensis* fluctuates through the variation in numbers in each size class. Using a spectral density or power with 2 different distance (5cm and 3cm) for spectrum analysis, it is shown that *A. yuanbaoshanensis* process its life relying on its basic spectrum; for the basic spectral A0 being constantly the biggest amplitude disregarding spectral density of distance 5cm or that of 3cm (e. g. using 3cm as distance of size class, that it can be divided into 15 class; Ai represent a fluctuated period, which A0=15×3= 45cm (DBH) period, A1=15×3/3=15cm period, A5=15×3/6=7.5cm period, and A7=15×3/8=6cm period). This is proved that *A. yuanbaoshanensis*'s life history tends to be controlled by its biological characteristics. The fluctuations in numbers are associated with population restoration through local canopy gap effects. The sizes and the number of such gaps differ spatially and over time to produce the observed ratios of size class and age structure. This, then, indicates that the population has been stable and has regenerated well.

The survival curve of *A. yuanbaoshanensis* is sorted out to be Deevey Type Ⅲ, although there is an evidence of disorder within the survival curve. The peak is probably during the gap period, when the small plants more chance to survive; hence, releasing them to grow into the main layer. The dip point might be due to the time when the main canopy layer is overloaded, leading less opportunity for small plants to grow into the upper layer. There is very high mortality in young small plants, but this declines as they grow larger. There is very high mortality in young small plants, but this declines as they grow larger. However, because of inter-and intra-specific competition and environmental impact, the numbers dramatically decrease during transition periods of seedling → sapling, sapling→arboret, 3rd sub-layer→2nd sub-layer of trees, and 2nd sub-layer→1st sub-layer. The low survival rate of small plants means that only a small proportion is recruited to the 1st sub-layer of the canopy.

During several years of investigation in the Yuanbaoshan forest, we found that *A. yuanbaoshanensis* is a mast seeding tree with a 3 or 4 year-seeding cycling and varying amounts of seeds set in different years. Therefore, its cost for reproduction is relatively high. There was no seeding in 1992 and 1996, but 3 seeding plants (31 adult, DBH≥ 20cm) with each bearing 14～18 cones in 1999, and 4 seeding plants each with 30～263 cones in 2000. The amount of seed is variable not only according to years, but also for individual plants. In 2 to 3 of the years the population did not seed. The cones were concentrated in the mid to upper tree crowns, and these accounted for 90% of the total seed amount, Cones were generally on the eastern side of trees. Low seed quantity, low kernel plumpness (around 40%), extremely low germination rate (6.8%～18.9%), high density-dependent mortality among seedlings, and low fitness of seeds and seedlings might be the key risks to *A. yuanbaoshanensis*.

The *A. yuanbaoshanensis* exhibits an intensively clumped distribution, The size groups, S1, S2, S3 and S4, are clumped spatially, but size classes S4 and S5 show a more random or even distribution. Both composition and structure of the community are the essential factors to affecting spatial distribution and pattern. There is no evidence of genetic differentiation when 4 sub-populations were sampled. Nei (1973)'s gene diversity index H, of the *A. yuanbaoshanensis* 0.1710, while Shannon population diversity index I is 0.1735. Low genetic variation is possibly the result of a restricted evolutionary potential, therefore making it difficult to exploit a new habitat and spread the population. This illuminates that the population is "very vulnerable".

Large numbers of ramets of *Taxus chinensis* var. *mairei*, are generally clustered as a group, sprout on the trunks of standing adult trees or on fallen trees. As they grow larger, these clonal plantlets require a large space with consequently increased competition, leading to a large number of plants deaths. The transition of plantlet→ sapling→ and arboret, the population was accompanied by high mortality. When growing up as arborets, despite being bound to the genet trees, the individual plants establish their

own adventitious roots system, occupying their essential micro habitat space. The standing ramets maintain low mortality and have better ability to utilize the resources of their environment. Then they demand more resources as they grow, and the connections between individual plants break down. In this case, the competition between ramets and among ramets and genets are concurrent and results in the ramets' high morality. The population then tends to be stable after some ramets are eliminated. At this point, mortality rises again as they grow up to be adult. The dynamic of the population number is chiefly controlled by its internal (genet-level) mechanisms and to environmental conditions as well.

The clonality and ramet population of the *T. chinensis* var. *mairei* regularly group at the genet's center, and as the species is usually found in rocky, humid gullies, habitat heterogeneity may constrain the clonal plants and confine them to a space to which they are best adapted, thus producing a clumped distribution. Due to the inter-and intra-species competition, the degree of clumping is not very intensity. Ramets are clumped within a patch, however, the genet appears to be evenly distributed, i. e. patches of ramet are even. The pattern scale is 4 grid unit area, said 100 m^2.

Fractal theory helps one to understand the spatial distribution of *T. chinensis* var. *mairei* population. The box dimension and correlation dimension are high while the information dimension is low, revealing that the distribution pattern of *T. chinensis* var. *mairei* tends collectively to be un-clumped. The quantity of ramets is almost 5 times that of seedlings. Indeed seedlings are rarely found, suggesting that *T. chinensis* var. *mairei* regenerates essentially by the ramet clonality of a "guerilla" clonal architecture.

The clonal architecture index of different plots ranged from 0. 60 to 0. 87 indicating that the architecture is variable, like the environmental condition. This suggests that *T. chinensis* var. *mairei* clonal population has more morphological plasticity.

The reason that few seedlings found in the community, may be that the rocky habitat, with its dense *Fargesia nitida*. This species' root system intertexture forms a "cushion layer", making it difficult for seedling roots of *T. chinensis* var. *mairei* to reach the mineral soil. Also, as the seed of *T. chinensis* var. *mairei* requires one year of after-ripening many of its seeds may be rotted or predated before germination. Experimental trials also demonstrate high seedling mortality, showing its difficulty to environmental adaptation by sexual generation. By contrast, clonality may be a marked advantage by providing a stable "generation source" by a large quantity of ramets for the population. As well, the clonality of spreading risk can enhance population adaptation to the problem of habitat and then as a result will maintain and develop the population.

目　录

第一章　元宝山自然条件概况

第一节　地理地质条件

元宝山自然保护区位于桂北融水苗族自治县，北纬 25°22′～25°32′、东经109°07′～109°13′的范围内，面积 39km²，为贵州高原和广西盆地接壤的斜坡地带（见图 1-1）。区内山峦起伏、山势雄伟、沟谷纵横、流急坡陡，为贝江、小环江、都柳江等水系的水源涵养林地之一。山脉呈南北走向，地势北高南低，属中山地貌，一般海拔 1000～1500m，主峰蓝坪峰海拔 2081m，为广西第三高峰。切割深度一般大于 500m，最大可达 1600m。元宝山自元古代就出露于海面成为陆地，为广西起源最古老的山体。元宝山地层属华南分区，出露的地层主要有中元古界四堡群、上元古界丹洲群，其形成年代可上溯至距今 16.7 亿～10 亿年前。本区主要岩石类型为粗粒（或中粗粒）斑状黑云母二长花岗岩，岩石一般呈浅灰或灰色，矿物成分为钾长石 28%～55%，斜长石（An5～20）12%～35%，石英 20%～48%，此外还含有少量黑云母、白云母等矿物。岩石为粗粒（或中粗粒）斑状花岗结构，矿物斑晶主要为钾长石，杂乱分布，粒径大小一般为 2～5cm，含量 8%～35%，局部钾长石与黑云母呈定向排列，显示片麻状构造。

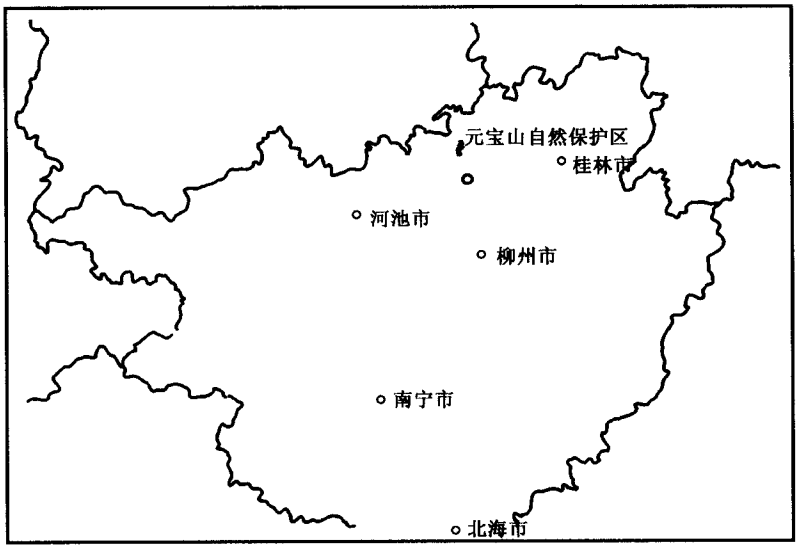

图 1-1　广西元宝山自然保护区地理位置示意图

Fig. 1-1　The orientation sketch of the Yuanbaoshan Nature Reserve

第二节　气候条件

元宝山属于典型的中亚热带湿润气候区，山地气候明显，太阳辐射比较强烈，日照