Postprint: Community Characteristics of Dipterocarpus retusus Forest in Niuluo River Nature Reserve

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Abstract

Dipterocarpus retusus Bl. is a National Grade I Key Protected Wild Plant and a characteristic tree species of Southeast Asian tropical rainforests. Currently, research on its community ecology remains a gap. Recently discovered in Niuluohe Nature Reserve, Jiangcheng County, the Dipterocarpus retusus forest is distributed at an elevation exceeding 1000 m, representing the highest altitude distribution of Dipterocarpus retusus forest in China. Through field surveys, four 30 m × 30 m community plots and twenty 10 m × 10 m population quadrats were established using typical sampling methods, recording species, plant height, diameter at breast height (DBH), quantity, community characteristics, etc. By employing methods such as distribution type classification, community species diversity analysis, and population age structure classification, the community and population characteristics of the Dipterocarpus retusus forest were analyzed. The results showed that: (1) A total of 181 seed plant species belonging to 76 families and 143 genera were recorded in the plots, among which 58 families, 126 genera, and 162 species were of tropical nature, with tropical components accounting for 76.32%, 88.11%, and 89.50% at the family, genus, and species levels, respectively, indicating the strong tropical nature of this community; (2) The species diversity indices of the Dipterocarpus retusus community were generally high, with diversity indices (dMa, H') showing the pattern of shrub layer > tree layer > herb layer across different community layers; the evenness index Jsw was relatively similar across different layers; the dominance index D showed the pattern of herb layer > tree layer > shrub layer. (3) Importance values of the tree layer indicated that Dipterocarpus retusus had the highest importance value at 26.85, demonstrating absolute dominance as the dominant and constructive species of this community; (4) The population age structure of Dipterocarpus retusus was a positive pyramid type, indicating that the population is in a growth period and is a growing population.

Full Text

Abstract

Dipterocarpus retusus Bl. is a nationally protected wild plant (Class I) and a flagship species of tropical rainforests in Southeast Asia. Currently, research on its community ecology remains largely unexplored. A recent discovery in the Niuluo River Natural Reserve, Jiangcheng County, revealed D. retusus forests distributed at elevations exceeding 1000 m, representing the highest known altitude for this species in China. This study employed field surveys and typical sampling methods to establish four 30 m × 30 m community plots and twenty 10 m × 10 m population quadrats. We recorded species composition along with plant height, diameter at breast height (DBH), abundance, and community characteristics. Through analysis of distribution types, community species diversity, and population age structure, we characterized the community and population features of the D. retusus forest. The results showed: (1) A total of 181 seed plant species belonging to 143 genera and 76 families were recorded. Among these, 58 families, 126 genera, and 162 species exhibited tropical affinities, accounting for 76.32%, 88.11%, and 89.50% of the total families, genera, and species, respectively, indicating a strong tropical nature. (2) Species diversity indices were generally high, with diversity indices (dMa, H') showing the pattern shrub layer > tree layer > herb layer across different strata; evenness index (Jsw) was relatively similar among layers; and dominance index (D) showed the pattern herb layer > tree layer > shrub layer. (3) Importance value analysis of the tree layer revealed that D. retusus had the highest importance value at 26.85, demonstrating absolute dominance as the community' s constructive species. (4) The population age structure of D. retusus exhibited a positive pyramidal shape, indicating a growing population in an expansion phase.

Keywords: Dipterocarpus retusus, flora, species diversity, importance value, age structure, Niuluo River Natural Reserve

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Introduction

Plant communities constitute the material foundation for maintaining ecosystem stability and sustainable productivity. Community species composition, diversity, and structure not only reflect responses to ecological environments but also represent comprehensive expressions of plant biological and ecological characteristics, thereby indicating community stability and habitat heterogeneity. Flora represents the sum total of all plants in a given region (or period, or taxonomic group), resulting from evolutionary development under specific natural geographical conditions and serving as both a reflection of the natural environment and an important basis for plant classification. Therefore, studying regional flora is essential for understanding vegetation distribution patterns. Species diversity serves as a crucial indicator of community charac-

teristics, playing a significant role in reflecting habitat differences, community structural composition, and stability. Population age structure refers to the proportion and distribution of individuals across different age groups within a population, which not only reflects population size and distribution status but also reveals population dynamics. Consequently, investigating the composition and species diversity characteristics of D. retusus communities is theoretically important for understanding the current status of protected communities and practically significant for population conservation and management.

As dominant canopy species in Southeast Asian rainforests, Dipterocarpaceae species hold important ecological status and substantial economic value. Dipterocarpus retusus is a tall tree species in the family Dipterocarpaceae, genus Dipterocarpus, and is classified as a nationally protected wild plant (Class I). It is primarily distributed in southeastern Yunnan (Hekou, Jinping, Pingbian, Lüchun, Jiangcheng along the lower Mekong River) and western Yunnan (Yingjiang County), as well as southeastern Tibet. Literature records indicate that D. retusus forests typically occur in valley habitats below 500 m elevation, sometimes extending up to 700 m. Our investigation in the Niuluo River Natural Reserve, Yunnan, revealed D. retusus forests distributed between 1000–1100 m, representing the highest elevation record for this species in China. While community characteristics of other Dipterocarpaceae species such as Parashorea chinensis, Hopea hainanensis, and Vatica mangachapoi have been extensively studied, research on D. retusus remains scarce. This study selected D. retusus in the Niuluo River Natural Reserve as the research object. First, we analyzed community floristic composition to understand structural characteristics. Second, we examined community species diversity indices to reveal diversity patterns. Finally, we applied population age structure models to analyze future population dynamics and trends, providing a scientific basis for conservation and sustainable utilization. This record of D. retusus forest in Niuluo Reserve represents the highest elevation distribution in China, which is significant for defining Yunnan' s tropical rainforest types and delineating tropical regions in Yunnan. It can serve as a seed source and site selection reference for future D. retusus forest establishment and as an important base for studying high-elevation D. retusus populations and forest communities.

1 Study Area Overview

The Niuluo River Natural Reserve is located in southern Jiangcheng County, Yunnan Province, with geographical coordinates of 23°19' 23" -23°45' 50" N, 101°50' 3"-102°21' 32" E. This region represents a typical tropical biogeographic zone in mainland China, where many typical Southeast Asian tropical species are distributed, holding important significance for botanical and vegetation research and conservation in China. The elevation ranges from 879 to 1431 m, with a mean annual temperature of 18.7°C and average annual precipitation of 2283 mm. Despite small elevation differences, the area features high temperature and humidity with abundant rainfall.

2 Methods

2.1 Plot Establishment and Survey Content

The study area encompassed three D. retusus community fragments (F1, F2, F3) distributed in a belt pattern along moist gully edges at 1025–1037 m elevation. Fragments F1 and F3 were relatively small (~0.1 ha), while F2 was larger (~1 ha). Based on topography and community size, we employed typical sampling methods to establish four 30 × 30 m community plots, within which 10 × 10 m population quadrats were arranged in a quincunx pattern. Fragment F2 contained two community plots with ten population quadrats, while F1 and F3 each contained one community plot with five population quadrats. Community plots recorded habitat factors including slope aspect, slope gradient, elevation, GPS coordinates, and microtopographic characteristics, along with species names, DBH, height, coverage, abundance, vitality, and phenology. All trees with DBH 5 cm were measured. Population quadrats surveyed only D. retusus individuals, recording abundance, height, DBH, and growth condition.

2.2.1 Floristic Analysis of Families, Genera, and Species

Family and genus distribution types were classified according to the methods of Academician Wu Zhengyi and colleagues. Species distribution ranges were determined based on *Flora Yunnanica*, *Flora of China*, and *Flora of China* (English edition), with floristic components assigned accordingly. Following Li Haitao (2008) and Li Xiwen (1995), endemic species distributed in southern China—particularly southern Guangxi, Guizhou, Sichuan, Hainan, and southern Yunnan—were classified as tropical components, with reference to Zhu Hua' s methods.

2.2.2 Species Diversity Measurement

Community species diversity was assessed using four indices: dominance index, diversity index, evenness index, and richness index. Calculation formulas followed Ma Keping (1994):

Margalef richness index:

$$d_{Ma} = (S-1)/\ln N$$

Simpson dominance index:

$$D = 1 - \sum_{i=1}^{S} p_i^2$$

Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

Pielou evenness index:

$$J_{sw} = H' / \ln S$$

Where S is the number of species in the plot, N is the total number of individuals in the community (N = n + n + ···+ n), and p is the proportion of individuals of species i in the plot (p = n /N).

2.2.3 Importance Value Analysis

Importance value (IV) is a comprehensive indicator measuring species relative importance in a community, derived from relative abundance, relative frequency, and relative dominance. This analysis focused on tree species:

Importance value:

$$IV = (relative\ abundance + relative\ frequency + relative\ dominance)/3$$

Relative frequency:

$$RF = \frac{\text{sum of frequencies of a species across all plots}}{\text{sum of frequencies of all species}} \times 100$$

Relative dominance:

$$RD = \frac{\text{basal area of a species}}{\text{total basal area of all individuals in the plot}} \times 100$$

Basal area:

$$BA = \pi \times (DBH/2)^2$$

Where is the circumference ratio and DBH is diameter at breast height. Relative abundance = (number of individuals of a species / total number of individuals of all species) × 100.

2.2.4 Diameter Class Classification for Dipterocarpus retusus

Population age structure characteristics were analyzed using diameter classes as age class surrogates, combined with height (H) and DBH factors. The population was divided into six classes: Class I: seedlings, 0 < H < 50 cm; Class II: saplings, H 50 cm, DBH < 5 cm; Class III: small trees, 5 DBH < 10 cm; Class IV: medium trees, 10 DBH < 20 cm; Class V: adult trees, 20 DBH < 40 cm; Class VI: large trees, DBH 40 cm.

3 Results

3.1 Floristic Composition

A total of 204 vascular plant species belonging to 161 genera and 90 families were recorded across the four community plots, including 181 seed plant species (137 dicots in 108 genera and 60 families; 43 monocots in 34 genera and 15 families) and one gymnosperm species (one family, one genus, one species).

Family-level analysis: The flora comprised eight distribution types, with pantropical distribution dominating at 41 families (53.95% of total families), followed by cosmopolitan distribution at 11 families (14.47%). Other types such as north temperate and East Asian–North American disjunct distributions accounted for only 6.58% and 2.63%, respectively. This indicates strong tropical origins at the family level.

Genus-level analysis: The flora comprised ten distribution types and seven variants, with pantropical distribution and tropical Asian (Indo-Malaysian) distribution dominating at 38 genera (26.57%) and 37 genera (25.87%), respectively. Tropical Asian genera included *Alseodaphne*, *Knema*, and *Crypteronia*, while pantropical genera included *Aristolochia*, *Piper*, and *Glochidion*. Similar to the family level, the genus-level composition shows strong tropical affinities.

Species-level analysis: The flora comprised six distribution types and eight variants, with tropical Asian (Indo-Malaysian) distribution and Vietnam (or Indochinese Peninsula) to South China distribution dominating at 52 species (28.73%) and 31 species (17.13%), respectively. Tropical Asian species included *Ardisia japonica*, *Zingiber mioga*, and *Dioscorea opposite*, while Vietnam-to-South China species included *Lithocarpus gagnepainianus*, *Talauma hodgsonii*, and *Knema furfuracea*. Overall, tropical components accounted for 89.50% of species, while temperate components comprised 9.39%. The species-level composition thus exhibits even stronger tropical characteristics than family and genus levels, with predominant tropical Asian (Indo-Malaysian) affinities indicating strong Malaysian relationships.

In summary, the D. retusus forest community demonstrates strong tropical characteristics across family, genus, and species levels, confirming its tropical origin.

3.2 Community Species Diversity Indices

The three D. retusus distribution sites in Niuluo Natural Reserve occurred along gully edges at 1025–1037 m elevation with slopes of 10°–30°. The community could be stratified into three layers: upper tree layer (>20 m height, canopy coverage 30–50%), lower tree layer (5–20 m, coverage 50–60%), shrub layer (1.5–5.0 m, coverage 30–40%), and herb layer (~1 m, occasionally up to 5 m for wild bananas). The upper tree layer was dominated by tall D. retusus individuals mixed with *Lithocarpus fenestratus*, *Alseodaphne andersonii*, and *Sarcosperma arboretum*. The shrub layer was also dominated by D. retusus, indicating its high dominance in both tree and shrub layers. The herb layer showed considerable

variation across sites (coverage 25–50%). Lianas were sparse, including *Rhaphidophora decursiva*, *Pholidota chinensis*, *Lemmaphyllum microphyllum*, and *Neottopteris nidus*. Community physiognomy showed some deciduous species in the upper tree layer (e.g., *Acer oblongum*) with distinct seasonal changes, while lower layers remained evergreen year-round.

[Figure 1: see original paper]

Tree layer species richness index (dMa) ranged from 4.40 to 6.21, with S2 showing the maximum value. Dominance index varied significantly (0.45–0.86), while diversity indices were generally high. Shrub layer species richness ranged from 5.20 to 8.02, with substantial variation; S2 shrub layer diversity indices (dMa and H') reached maximum values of 8.02 and 3.66, respectively, while other plots showed smaller differences. Herb layer species richness ranged from 4.05 to 6.19, with S4 showing the maximum value.

Structurally, communities F1 and F2 exhibited dMa and H'indices in the pattern shrub layer > tree layer > herb layer, while D index showed herb layer > tree layer > shrub layer, and Jsw index showed tree layer > shrub layer > herb layer. Community F3 showed dMa, H' , and D indices in the pattern herb layer > shrub layer > tree layer, while Jsw index showed shrub layer > herb layer > tree layer.

3.3 Tree Layer Species Importance Values

The tree layer comprised 59 species and 424 individuals. Twenty-two species with importance values >1 accounted for 352 individuals (Table 4), with a cumulative importance value of 75.73. Dipterocarpus retusus had the highest importance value (26.85), followed by *Alseodaphne andersonii* (4.68), *Alseodaphne petiolaris* (4.58), and *Sarcosperma arboreum* (4.45), all substantially lower than D. retusus. This demonstrates D. retusus as the absolutely dominant constructive species, with other species serving as companions.

Among the 22 species with importance values >1, 15 exhibited tropical Asian (Indo-Malaysian) distribution (e.g., *Ostodes paniculata*, *Sarcosperma arboreum*, *Baccaurea ramiflora*, *Alseodaphne andersonii*), while four showed tropical Asian to tropical Australasian distribution (e.g., *Garcinia cowa*, *Crypteronia paniculata*, *Morus macroura*, *Walsura robusta*). This confirms that the tree layer is dominated by tropical Asian elements.

3.4 Population Age Structure

Population age structure diagrams objectively reflect current population status and intuitively demonstrate future development trends. Age structures are typically classified as growth type (typical pyramid), stable type (bell-shaped), or 衰退型 (decaning type). Statistical analysis of D. retusus individuals in population quadrats yielded the following results (Figure 2): Class I: 413 individuals; Class II: 189; Class III: 116; Class IV: 96; Class V: 58; Class VI: 33. Class I

accounted for the largest proportion (45.63%), Class VI the smallest (3.64%), Class II comprised 20.88%, and Classes III and V accounted for 12.81% and 10.61%, respectively.

The age structure of fragment F1 showed similar numbers of Class II and Class IV individuals, indicating balanced intra- and interspecific competition where space and resources were no longer primary limiting factors, suggesting a stable population. Fragment F2 exhibited a pyramidal age structure, indicating a growing population. Transition from Class I to II showed 102 of 235 individuals surviving (mortality 56.60%), with subsequent mortality rates of 43.14% (II to III), 18.97% (III to IV), 36.17% (IV to V), and 40% (V to VI). While seedlings were abundant, mortality was high. Fragment F3 also showed a pyramidal structure with mortality rates of 59.54% (I to II), 50.94% (II to III), 26.92% (III to IV), 26.32% (IV to V), and 35.71% (V to VI), indicating generally high mortality.

In summary, the D. retusus population in the reserve is in a growth phase with a growing population structure but experiences high mortality. Individual numbers decreased progressively from Class I to VI, with the greatest fluctuation between Classes I and II and numerous dead trees, indicating abundant seedlings but difficulty transitioning to Class II. Mortality decreased from Class II to IV as individuals required more space and resources, with intra- and interspecific competition maintaining relatively high but stable mortality levels.

[Figure 2: see original paper]

4 Discussion and Conclusion

(1) Floristic Composition

In the D. retusus forest flora, tropical families accounted for 76.32% of total families, tropical genera for 88.11%, and tropical species for 89.50%. Tropical elements dominated across family, genus, and species levels, demonstrating strong tropical characteristics and confirming this region as a typical tropical biogeographic zone in China. Among tropical genera and species, tropical Asian types were most numerous, showing strong tropical Asian affinities. Geographically, the Niuluo River D. retusus forest is adjacent to Xishuangbanna D. retusus forest, sharing similarities as northern marginal types of Southeast Asian dipterocarp forests within the same rainforest formation, yet showing differences. Xishuangbanna D. retusus forests had slightly higher proportions of tropical families (78.9%), genera (94.1%), and species (>90%). Additionally, Niuluo River' s canopy height was below 45 m, considerably lower than Xishuangbanna' s 70 m canopy. These differences are largely related to Niuluo River' s more northerly latitude and higher elevation, though other factors require further investigation.

(2) Community Diversity Indices

Diversity indices are influenced by site conditions (topography, climate, soil, hydrology), stand density, and human disturbance. Community F2 showed higher tree layer richness indices but lower herb layer diversity indices compared

to F1 and F3, primarily because well-developed tree layers inhibited understory herb development, consistent with field observations. F1 and F2 showed dMa and H' indices in the pattern shrub layer > tree layer > herb layer, but for different reasons: F1' s shrub and herb dominance resulted from reduced canopy cover due to human disturbance, alleviating light and moisture limitations, while F2's pattern was due to numerous young D. retusus individuals in the understory. F3' s herb layer showed the highest dMa and H' indices because S3 was located at the community edge beneath a canopy gap, where rapid herb growth created unfavorable conditions for woody seedling establishment. F3' s higher shrub layer dominance index compared to F1 and F2 also resulted from the gap-created microenvironment favoring seed germination and seedling growth.

(3) Importance Value Structure
Community tree species importance values showed D. retusus (IV = 26.85) far exceeding other species as the main dominant species. Other species such as *Alseodaphne andersonii*, *Alseodaphne petiolaris*, and *Sarcosperma arboreum*, despite ranking high in importance values, served only as companion species. This dominance may be attributed to D. retusus' s large, high-moisture seeds that limit wind dispersal distance, causing most seeds to fall near parent trees and resulting in concentrated distributions with numerous young individuals, rapid growth, high understory closure, and low light availability that inhibits other species. Whether this results from microhabitat specialization or long-term adaptation requires further study.

(4) Population Age Structure
The D. retusus community represents a growing population with continuous regeneration capacity, ensuring its dominance for the foreseeable future. However, this is accompanied by high birth and death rates. Field surveys revealed abundant seedlings but few large trees, reflecting high mortality between age classes, particularly the transition from Class I to II where only a small fraction survives. This may be caused by physiological mechanisms, making understanding these mechanisms key to maintaining stable population development and improving seedling survival. Alternatively, high mortality may result from extreme habitats. Whether the high number of young individuals results from high germination rates or high seed production requires further investigation.

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References

Chinese Botanical Society Editorial Board of Chinese Academy of Sciences, 1990. *Flora of China* [M]. Beijing: Science Press, 50(2): 116.

HAN L, WANG JQ, WANG HZ, et al, 2014. The population structure and dynamics of *Populus euphratica* at the upper reaches of the Tarim River[J]. *Acta Ecologica Sinica*, (16): 4640-4651.

Kunming Institute of Botany, Chinese Academy of Sciences, 1997. *Flora Yunnanica* (Vol.5)[M]. Beijing: Science Press, 1-870.

JIANG ZG, MA KP, HAN XG, 1997. *Conservation Biology*[M]. Hangzhou: Zhejiang Science and Technology Press.

JIN H, ZHAO Y, ZHAO W, et al, 2017. Elevational changes in species diversity and similarity analysis of a *Rhododendron chrysanthum* community on Changbai mountain[J]. *Acta Ecologica Sinica*, 35(1): 125-133.

LI XW, 1995. A floristic study on the seed plants from tropical Yunnan[J]. *Acta Botanica Yunnanica*, (2): 115-128.

LI HT, DU F, WANG J, 2008. Studies on floristics of seed plants in Yuanjiang nature reserve in Yunnan Province[J]. *Journal of Tropical and Subtropical Botany*, 16(5): 446-451.

LI B, 2000. *Ecology*[M]. Beijing: Higher Education Press: 46.

LU X, LAN QY, YANG MZ, 2010. Research advancement of Dipterocarpaceae seeds characteristics[J]. *Seed*, 29(5): 46-50.

Ministry of Forestry and Agriculture, 1999. National wild plants list for protection (I)[J]. *Chinese Journal of Plant*, (5): 4-11.

MA CC, DAI J, XIAO ZQ, et al, 2017. Community structure and distribution of minimum population species of *Myristica yunnanensis*[J]. *Guihaia*, 37(06): 783-790.

SUN RY, LI B, ZHU GY, et al, 1993. *General Ecology*[M]. Beijing: Higher Education Press: 46.

TAO GD, TONG SQ, 1982. Materials for Chinese Dipterocarpaceae[J]. *Acta Botanica Yunnanica*, (4): 345-346.

WANG DM, YANG SZ, ZHU RX, 1985. The Dipterocarpaceae forests in Yunnan province[J]. *Acta Phytoecologica et Geobotanica Sinica*, (01): 32-45.

WU ZY, 1991. The distribution types of Chinese seed plants[J]. *Acta Botanica Yunnanica*, 13(Supplement): 1-139.

WU ZY, ZHOU ZK, LI DZ, et al, 2003. The areal-types of the world families of seed plants[J]. *Acta Botanica Yunnanica*, (3): 245-257.

WANG JF, ZHENG XX, 2015. Evergreen broad-leaved forest secondary forest species diversity community succession in Sanming of Fujian[J]. *Journal of Northwest Forestry University*, 30(05): 39-45.

XUE JH, 2006. *Forest Ecology*[M]. Beijing: China Forestry Press: 78-80.

XIU C, OUYANG ZY, ZHENG H, 2014. Flora analysis of riparian vegetation in Yongding-Haihe river system, China[J]. *Acta Ecologica Sinica*, 34(6): 1535-1547.

YANG SZ, WANG DM, ZHU RX, 1983. Yunnan Dipterocarpaceae tree species[J]. *Yunnan Forestry Science and Technology*, (01): 1-13.

YANG YM, WANG J, PEI SJ, et al, 2012. Yunnan province comprehensive biogeographic division[C]. National Biodiversity Conservation and Continued Use of Seminars.

ZHANG JQ, WANG LZ, 1985. Geographic distribution of Dipterocarpaceae[J]. *Chinese Bulletin of Botany*, 3(5): 1-8.

ZHANG JL, 1989. *Main Timber in Xishuangbanna* (I) [M]. Beijing: Forestry Press: 22-30.

ZHU H, 1990. Tropical rain forest vegetation in Xishuangbanna[J]. *Tropical Geography*, 10(3): 233-240.

ZHU H, 1993. Floristic plant geography on the Dipterocarpaceae forests of Xishuangbanna[J]. *Acta Botanica Yunnanica*, (3): 233-252.

ZHU H, 2000. *The Study on Ecology and Biogeography of Dipterocarpaceae Tropical Rain Forest in Xishuangbanna*[M]. Kunming: Yunnan Science and Technology Press: 1-245.

ZHANG XL, ZHOU JH, CAI WT, et al, 2017. Diversity characteristics of plant communities in the arid desert of the Heihe basin under different moisture gradients[J]. *Acta Ecologica Sinica*, 37(14).

ZHANG JT, 1995. *Methods of Quantitative Vegetation Ecology*[M]. Beijing: China Science and Technology Press.

Note: Figure translations are in progress. See original paper for figures.