# Community Structure and Environmental Interpretation of the Chinese Endemic Plant Osmanthus serrulatusRehd. Postprint

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## Abstract

To investigate the effects of environmental factors on Osmanthus serrulatus plant communities, this study examined environmental factors, TWINSPAN classification, and DCCA ordination of species and diversity indices in relation to environmental factors in the Donglashan Osmanthus serrulatus plant community region of Baoxing County, Sichuan Province. The results indicated that: 1) TWINSPAN classified the 24 Donglashan Osmanthus serrulatus plant communities into 12 community types, with the classification results spatially reflecting successional trends of plant communities in Donglashan. 2) Osmanthus serrulatus plant communities occur in gullies characterized by high soil water content, high canopy density, and southwest and south aspects. The main companion species of Osmanthus serrulatus communities include Carpinus turczaninowii, Litsea moupinensis, Euptelea pleiosperma, Rhododendron fortunei, Lysimachia baoxingensis, Phlomis umbrosa, and Asplenium trichomanes. 3) DCCA ordination results validated the TWINSPAN classification results and revealed that the key environmental factors influencing community types and spatial distribution of Donglashan Osmanthus serrulatus plant communities are soil organic matter and humus content.

## Full Text

## Analysis of Community Structure of *Osmanthus serrulatus* Based on TWINSPAN Classification and DCCA Ordination

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**Abstract**

Plant community classification and ordination are fundamental yet complex approaches in vegetation ecology that categorize communities based on characteristics to analyze ecological relationships between vegetation and environment. Western Sichuan' s mountainous plateau terrain and unique geographic conditions support abundant plant species but complicate classification due to environmental heterogeneity. To understand how environmental factors influence *Osmanthus serrulatus* communities, this study investigated environmental variables, TWINSPAN classification, species composition, diversity indices, and Detrended Canonical Correspondence Analysis (DCCA) ordination in Dongla Mountain, Baoxing County, Sichuan Province.

The results showed: (1) TWINSPAN divided 24 sample plots into 12 community types, revealing spatial successional trends; (2) *O. serrulatus* occurred in southwestern and southern slope ditches with higher soil moisture and canopy density, coexisting with companion species including *Carpinus turczaninowii*, *Rhododendron fortunei*, *Lysimachia baoxingensis*, *Litsea moupinensis*, and *Phlomis umbrosa*; (3) DCCA ordination verified the TWINSPAN classification and identified soil organic matter and humus content as the primary environmental factors influencing community type and spatial distribution.

**Keywords:** plant community; DCCA; environmental factor; *Osmanthus serrulatus*; TWINSPAN

## Introduction

*Osmanthus serrulatus* Rehd., also known as Baoxing osmanthus, is a Chinese endemic species in the Oleaceae family with high development potential. It is one of few spring-flowering species in the *Osmanthus* genus, with an extremely narrow distribution first discovered in Emei, Sichuan in 1916 and described by Rehder in *Plantae Wilsonianae*. While *Flora of China* recorded distributions in Sichuan and Fujian, recent findings have only been reported from Xiling Snow Mountain and Dongla Mountain in Sichuan. The Dongla Mountain population represents the world' s largest wild osmanthus community discovered to date, concentrated at 1800–2600 m elevation.

Previous research on *Osmanthus* has focused primarily on *O. fragrans* and *O. heterophyllus*, with minimal work on *O. serrulatus*. Molecular studies include transcriptome microsatellite characterization and carotenoid biosynthesis gene expression analysis by Chen Lin et al. Growth and development research is limited to seed germination mechanisms by Yang Guodong et al. Community-level studies consist only of preliminary niche research on dominant species by Chen Junhua et al. in Dongla Mountain, Sichuan, lacking in-depth investigation of species composition and diversity.

Plant communities result from integrated effects of climate, topography, and other factors across spatial scales. Quantitative classification and ordination are essential tools for revealing vegetation-environment relationships. Since their introduction, Two-Way Indicator Species Analysis (TWINSPAN) has dominated vegetation classification, while Detrended Canonical Correspondence Analysis (DCCA), developed from Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA), represents the latest ordination method. DCCA overcomes the arch effect, combines vegetation and environmental information with high precision, and has been successfully applied in plant community studies. While ordination expresses ecological relationships and aids classification interpretation, it is not a classification method itself. Combining environmental factors with classification remains limited. For example, Daibingguo quantitatively analyzed vegetation communities in eastern Liaoning mountains, identifying slope and phenology as key environmental factors. Özkan and Gülsöy used hierarchical analysis for ecological classification and mapping in Turkey' s Buldan forest district, finding altitude and longitude as primary factors affecting forest community types.

This study analyzes *O. serrulatus* communities in Dongla Mountain Grand Canyon, Baoxing County, Sichuan, using TWINSPAN classification and DCCA ordination to provide scientific basis for conservation and sustainable utilization.

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### 1. Study Area Overview

Dongla Mountain Grand Canyon is located in the Longmen Mountains at the transition from Sichuan Basin to Qinghai-Tibet Plateau, representing typical canyon landforms and alpine grassland ecosystems in western Sichuan. The study area (102.25°-102.95°E, 30.21°-30.69°N) features a subtropical monsoon humid climate with an average temperature of 7.2°C. Altitude ranges from 1800 to 5338 m, creating a vertical climate spectrum from subtropical to alpine permafrost zones with pronounced vertical zonation. Vegetation types include montane evergreen broadleaf forest, mixed evergreen-deciduous broadleaf forest, deciduous broadleaf forest, and subalpine coniferous forest, with well-preserved natural vegetation.

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## 2. Methods

**2.1 Sample Plot Setup and Data Collection** In the concentrated distribution area of *O. serrulatus* in Dongla Mountain, Baoxing County, we established 20 m × 20 m community quadrats. For the tree layer, all individuals with diameter at breast height  2 cm and height  1.5 m were surveyed, recording species name for each individual. Shrubs, herbs, and interlayer plants were completely surveyed in each quadrat, with species recorded.

Importance value (IV) was used as the dominance index for each plant species in the community, representing functional status. The importance value for tree and shrub layers was calculated as: (relative density + relative dominance + relative frequency)/3, where relative dominance used relative basal area for trees and relative coverage for shrubs.

Species diversity was calculated using: (1) Margalef richness index: (S-1)/lnN; (2) Simpson dominance index: $1-\Sigma Pi^2$; (3) Shannon-Wiener index: -ΣPi lnPi; and (4) Pielou evenness index: H' /lnS, where Pi is the proportion of individuals of species i, S is total species number, and N is total individuals.

Slope position and aspect were scored based on theoretical gradients. Slope position was categorized as ridge, upper, middle, lower, and valley slopes. Aspect scoring assigned highest values to south-facing slopes, followed by southeast and southwest, then east and west, with northeast and northwest receiving lowest values, as southern slopes receive stronger light and heat.

Soil samples were collected using the five-point cross method from 0–20 cm depth in each quadrat. Samples from five points were mixed, air-dried, processed, ground, and passed through a 100-mesh sieve for chemical analysis. Soil organic matter was measured by potassium dichromate oxidation with external heating, and soil humus by sodium pyrophosphate extraction with potassium dichromate.

**2.2 Data Analysis** CANOCO software requires two data matrices: vegetation data (species importance values) and environmental factors (altitude, slope position, aspect, slope ratio, soil organic matter, and soil humus). We used PC-ORD 4.0 for TWINSPAN classification and CANOCO for DCCA ordination following established protocols. Monte Carlo testing was performed to assess ordination axis significance. The first two axes were used for interpretation as they capture the primary environmental gradients.

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## 3. Results

**3.1 TWINSPAN Classification** TWINSPAN analysis of 24 plots grouped them into 12 community types based on ecological similarity. Each community was named according to dominant tree species, which also served as indicator species. This objective classification revealed relationships between vegetation and physical environment, with indicator species reflecting habitat characteristics.

The 12 community types were: - **Type I:** Dominated by *Salix moupinensis* and *O. serrulatus*, with *Lysimachia baoxingensis* - **Type II:** Dominated by *Swida scabrida* and *O. serrulatus* - **Type III:** Dominated by *Meliosma myriantha* and *O. serrulatus* - **Type IV:** Dominated by *Carpinus turczaninowii* and *O. serrulatus* - **Type V:** Dominated by *O. serrulatus* with *Tiarella polyphylla* - **Type VI:** Dominated by *Litsea moupinensis* - **Type VII:** Dominated by *Rhododendron fortunei* with *Polypodium petiolosum* - **Type VIII:** Dominated by *Tsuga chinensis* and *Litsea moupinensis* - **Type IX:** Dominated by *Stranvaesia davidiana* - **Type X:** Dominated by *Acer sinense* - **Type XI:** Dominated by *Pinus yunnanensis* - **Type XII:** Dominated by *Cercidiphyllum japonicum*

[Figure 1: see original paper] shows the study area location, [Figure 2: see original paper] shows the 24 sample plots, [Figure 3: see original paper] shows the TWINSPAN classification tree, and [Figure 4: see original paper] shows the classification matrix.

**3.2 DCCA Ordination Results** The cumulative contribution rate of the first two ordination axes was 76.4% for all species and 68.5% for dominant species (Table 2). Generally, cumulative contribution rates exceeding 50% adequately reflect community patterns. Axis 1 and Axis 2 eigenvalues were 1.124 and 0.764 for all species, and 1.302 and 0.735 for dominant species, respectively.

[Figure 5: see original paper] presents the two-dimensional DCCA ordination of 24 plots. Community types were distributed along environmental gradients: Types I and VIII clustered in the upper right, indicating cool-moist habitats; Types II, III, and IV were relatively concentrated with similar structure; Type V showed close relationships with slope and soil organic matter, distributed in gentle slope areas requiring sufficient water and deep soil; Type X was scattered, possibly due to adaptation to low soil depth and high light intensity; Type VII was distant from other groups, indicating unique habitat requirements.

**3.3 Environmental Gradient Analysis** DCCA effectively expressed the structural gradient of *O. serrulatus* communities and their relationship with environmental factors. Axis 1 primarily reflected the slope aspect gradient (shady to sunny slopes), while Axis 2 represented the slope gradient (steep to gentle slopes). The long arrows for soil humus and organic matter indicated strong relationships with community distribution. The acute angle between humus thickness and Axis 1 showed increasing humus content along Axis 1 from left to right.

The distribution of dominant species resembled community type patterns, indicating that dominant species largely determine community distribution. *O. serrulatus* (V11), *Carpinus turczaninowii* (V13), and *Euptelea pleiosperma* (V14) concentrated on the right side of Axis 1, in lower altitude sunny slopes with abundant water and heat conditions.

Table 3 shows the significance of environmental variables from the first DCCA axis. Soil organic matter, soil humus, and aspect were highly significant ($p < 0.01$) for both all species and dominant species.

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## 4. Discussion

The TWINSPAN classification and DCCA ordination provided a robust framework for analyzing *O. serrulatus* communities. The 12 community types reflected transitions from forest to shrubland and shrub to herbaceous communities, with environmental gradients corresponding to structural gradients. DCCA overcame limitations of other methods by independently completing classification while simultaneously expressing species and samples on ordination axes, providing greater ecological meaning.

Soil organic matter and humus content emerged as the most important factors influencing community distribution, consistent with findings that fertility conditions support species diversity. The complex terrain and humid climate of Dongla Mountain' s transitional zone create high habitat heterogeneity, with slope, aspect, and soil conditions playing crucial roles. While altitude and slope position showed less prominent effects, their influence cannot be ignored given the region' s unique topography.

*O. serrulatus* communities exhibited preferences for sunny, moist habitats with high canopy density, primarily on southern and southwestern slopes. The high species diversity similarity among communities reflects the area' s rich flora, though low resistance to disturbance makes these ecosystems vulnerable to human impacts. The fragmented distribution pattern suggests that future research should explore the species' ability to utilize limited resources in unique habitats, considering integrated effects of climate change and physiological characteristics.

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## 5. Conclusion

This study demonstrates that *Osmanthus serrulatus* communities in Dongla Mountain grow in moist, shaded ditch environments with high canopy density, predominantly on southern and southwestern slopes. Soil organic matter and humus content significantly influence community characteristics, while aspect and altitude have moderate effects. The communities show high inter-community species diversity similarity, supported by fertile soils that meet growth requirements of multiple species. The complex terrain and relatively closed natural environment have created exceptionally rich community diversity. However, low disturbance resistance makes these communities sensitive to human activities.

Environmental heterogeneity, particularly slope and aspect variations, significantly affects community distribution patterns. Conservation efforts should prioritize protecting these unique habitats and mitigating anthropogenic disturbances.

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