QUANTITATIVE CLASSIFICATION AND ORDINATION OF FOREST COMMUNITIES IN SOUTHEASTERN TIBET

LI, H. H. – LI, Z. H. – LI, Y. X. – JIAO, W. T. – YANG, X. L.*

Tibet Agricultural and Animal Husbandry University, Linzhi 860000, Tibet

**Corresponding author*
e-mail: jianma@inwascon.org.my

(Received 25th Oct 2023; accepted 8th Jul 2024)

Abstract. This study primarily employs the Twin Classification (TWINSPAN) and Canonical Correspondence Analysis (CCA) to investigate the original forest population types and distribution patterns in Southeastern Tibet. It also explores the main environmental factors causing structural variations in these forests. The results indicate the following: (1) Using TWINSPAN, the forest system in Southeastern Tibet was classified into eighteen community types. (2) Detrended Correspondence Analysis (DCA) and CCA ordination reveal that elevation, aspect, and slope are the primary environmental factors influencing the distribution of forest plant communities in Southeastern Tibet. (3) The TWINSPAN classification results, along with the conclusions from DCA and CCA ordination, illustrate the evolving spatial patterns of forest communities and their interactions with key environmental factors. This study provides a foundation for research on the conservation and sustainable development of forest communities in Southeastern Tibet, as well as relevant assessments of plant populations.
Keywords: *forest communities, species distribution, TWINSPAN, DCA, CCA*

Introduction

Vegetation type analysis mainly utilizes mathematical and scientific techniques to conduct morphological classification surveys. It aims to identify the relationships between plants and the ecological interactions between vegetation and the natural environment, revealing certain morphological patterns. Plant community classification and ordination are essential methods for understanding the morphological characteristics of vegetation within a specific region. They provide a crucial foundation for biodiversity classification in plant communities. Vegetation quantitative classification helps to accurately and objectively discover the ecological characteristics of vegetation populations and the interactive patterns between plants and the natural environment. It is an important approach in studying plant ecology (Zhang, 2011). Common methods for plant classification include Twin Classification (TWINSPAN) and cluster regression, while ordination is an important analytical method for studying vegetation changes, interpreting species distribution patterns, and their relationship with the environment. Methods such as Detrended Correspondence Analysis (DCA), Canonical Correspondence Analysis (CCA), and Detrended Canonical Correspondence Analysis (DCA) are also commonly used (Su et al., 2010; Wu et al., 2013). Abbas et al. (2021) used this method to study riverine plants in the Aswan Reservoir in Egypt, Hatim et al. (2021) studied plants in the Sinai Desert, Lysenko et al. (2021) studied grasslands in the Polesia region of Western Ukraine, and Rahman et al. (2020) conducted classification research on plant communities in the Himalayan alpine pastures in Pakistan. They all utilized Twinspan clustering, demonstrating the effectiveness of this method in plant classification.

Southeast Tibet is located in the southeastern part of Tibet, and its unique climatic conditions have resulted in diverse community types. It is recognized as one of the 200

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

globally significant biogeographic regions for biodiversity conservation by the World Wildlife Fund (WWF) (Wang et al., 2007). Forest vegetation is the primary component of natural plant communities in Southeast Tibet and plays a crucial ecological role in protecting the region's biodiversity and ecological balance.

As an integral part of natural ecosystems, forest communities are the products of interactions between biological populations and environmental factors. Current research on forest communities in Southeast Tibet has mainly focused on forest ecosystem structure and function, vertical zonation spectra, plant floras, and treeline vegetation (Wang et al., 2007; Ren et al., 2007; You et al., 2013). However, quantitative classification of forest communities has not been extensively studied. Important issues require investigation, such as identifying significant forest vegetation community types, understanding their distribution characteristics, and determining the environmental factors that influence the distribution patterns of forest communities. In this study, we employ the TWINSPAN classification, CCA ordination, and DCA ordination methods to analyze forest communities in Southeast Tibet. We aim to explore the relationships between their distribution patterns and the environment, as well as the main mechanisms driving the differences in forest community distribution. This research has significant implications for studying forest vegetation on the Qinghai-Tibet Plateau and enhancing ecosystem service functions.

Materials and methods

The study area is located in the Linzhi region of "Southeast Tibet," including Bayi, Gongbujiangda, Milin, Langxian, and Bomê counties (*Figure 1*). It is situated in the southeastern part of Tibet, along the middle and lower reaches of the Yarlung Tsangpo River, with geographical coordinates ranging from 92°11′ to 96°40′E and 28°41′ to 30°53′N (*Table 1*). The region is bordered by the Chamdo area to the east, and by the Nagqu area to the north, and shares boundaries with Lhasa City and Shannan Prefecture to the west and southwest (Yang et al., 2006). The annual precipitation is around 650 mm, with an average annual temperature of 8.7°C and an average sunshine duration of 2022 hours. The frost-free period lasts for 180 days. The average elevation of the area is 3100 m, and the terrain slopes from south to north. Influenced by diverse vertical climatic conditions, the region exhibits a complete vertical vegetation zone pattern (*Figure 2*). From low to high elevations, one can observe evergreen broadleaf forests, evergreen and deciduous broadleaf mixed forests, deciduous broadleaf forests, conifer and broadleaf mixed forests, coniferous forests, shrubs, meadows, and grasslands. The area holds significant research value in the study of vegetation ecosystems (You and Feng, 2013).

Research methods

Community survey

Field surveys were conducted from July 2020 to August 2022. The surveys mainly utilized online investigation methods. One representative plot was selected in different forest communities to describe the basic characteristics of the plot. GPS was used for positioning and measuring topographic features such as slope, aspect, and position. Nested plots were established within each plot to collect vegetation species and community structure data. The plot size was 20 m × 20 m, and four 5 m × 5 m shrub plots were set up within each plot. The selection of plot locations aimed to ensure relatively

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

homogeneous and natural habitats, ensuring representativeness of each plot. A total of 103 forest community plots were surveyed. Plant names, heights, coverage, and community coverage were recorded for each plot. Specimen sampling was conducted for unidentified species, which were then brought back to the laboratory for identification.

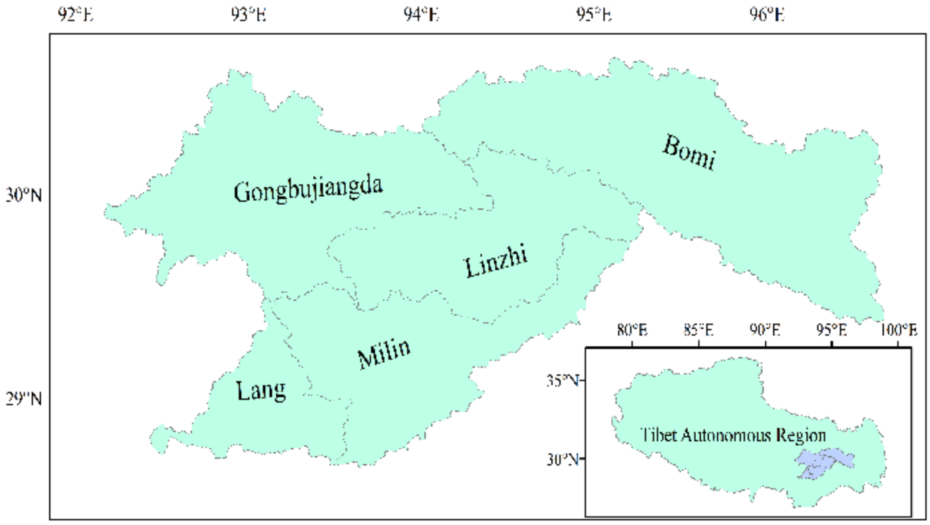

Figure 1. *Research area map*

Table 1. *A part of plot information*

Number	Altitude	Longitude	Latitude	Aspect	Slope	Cover degree
23	3010	92.29694444	28.9925	5	40	30
97	3067	92.393333	29.490592	280	10	70
103	3067	92.393333	29.490592	280	10	70
27	3160	93.88805556	29.02027778	30	5	70
28	3170	93.88805556	29.02027778	0	5	70
31	2858	94.43472222	29.445	0	5	50
1	4250	93.85076389	29.34690278	84	27	81
79	2720	94.48057222	30.33924167	90	5	50
51	4000	94.57916667	29.56861111	160	30	70
52	4100	94.58583333	29.56138889	165	30	75
52	4200	94.59583333	29.58666667	170	20	45
53	4400	94.61361111	29.60944444	170	20	30
54	4300	94.695	29.60472222	330	30	60
55	4200	94.69833333	29.61666667	330	30	50
59	3900	94.69833333	29.64111111	340	20	60
86	2210	94.7951	29.95021389	0	5	70
36	4000	94.82972222	29.46138889	0	0	40
33	3160	94.89638889	29.62361111	60	5	90
34	3120	94.91416667	29.61444444	5	5	100
94	3050	94.93138889	30.17416667	320	40	80
91	2560	95.61694444	29.98833333	255	40	60
73	3030	95.617525	29.98854722	90	15	100
92	2630	95.69861111	29.76972222	255	40	70
70	2765	95.7178	29.83264167	250	10	60
68	2980	96.01455	29.73977778	330	5	30
96	2096	96.34844722	29.61676056	110	50	60

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

Picea likiangensis var. linzhiensis *Quercus aquifolioides* *Juniperus tibetica*

Figure 2. *Sampling sites photos*

Data processing

The important value (IV) of a species was used as a quantitative indicator to describe its functional position in the community, representing the dominance of each species in the community. The calculation method for the importance value of trees is as follows:

$$IV = \frac{Hr + Cr + Fr}{3} \quad \text{(Eq.1)}$$

The calculation method for the importance value of shrubs is as follows (Wang and Shangguan, 2010):

$$IV = \frac{Hr + Cr}{2} \quad \text{(Eq.2)}$$

where Hr represents relative height, Cr represents relative coverage, and Fr represents relative frequency.

The importance value ranges from 0 to 1. A total of 103 forest vegetation plots were surveyed in the study area, recording 122 species of seed plants. The vegetation matrix consisted of the importance values of 122 tree and shrub species from the 103 plots, while the environmental attribute matrix comprised six environmental parameters from the 103 plots. Quantitative classification and ordination analysis were conducted separately for plots and species. Plot classification utilized the importance value data, while species ecological groups were based on binary attribute data (0,1). TWINSPAN was used for community classification, and CCA method was employed for ordination. The vegetation quantity classification was performed using TWINSPAN in Wintwins 2.3 (Hill, 1979), while CCA and DCA ordination of plots and environmental parameters were carried out using Canoco for Windows 4.5.

Vegetation classification units and naming

The vegetation classification units and naming followed the division system of the Qinghai-Tibet Plateau Integrated Scientific Expedition Team (1988). Vegetation types, formations, and communities were the primary units of vegetation classification. The naming of formations and communities adopted the dominant species nomenclature, where the main dominant species were listed in order of their dominance, and multiple co-dominant species within the same stratum were connected by "+".

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

Results and analysis

TWINSPAN quantitative classification of plots

A total of 103 plots were classified using TWINSPAN, and based on the principles of plant community classification and naming, combined with the ecological analysis of survey results and indicative or dominant species of community habitat characteristics, the plant communities in the study area were classified into 18 types, as shown in *Figure 3*.

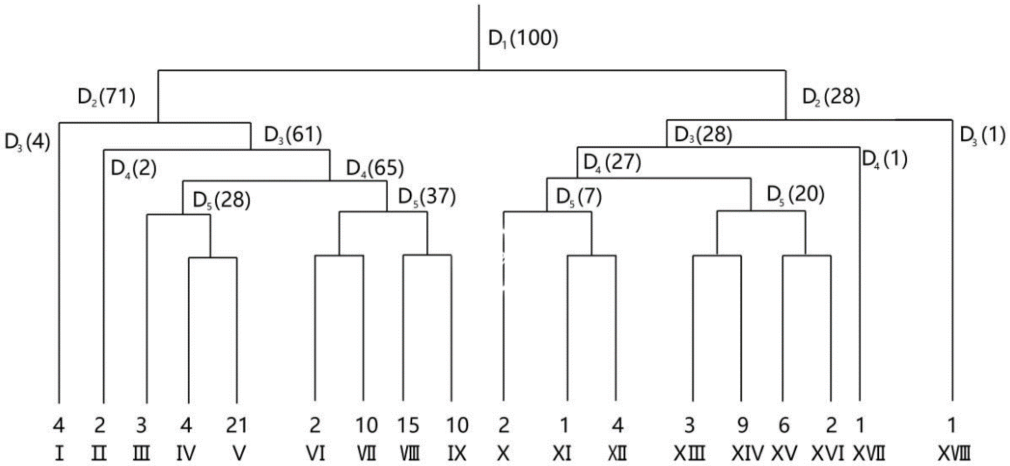

Figure 3. *TWINSPAN classification tree diagram of sample plots in the Linzhi area of southeastern Tibet*

Formation characteristics

I: *Juniperus tibetica* Forest Formation. Distribution altitude: 3800-4300m. It has a narrow distribution range and is mainly found on shady slopes and semi-shady slopes, with a community coverage of 60%.

II: *Cupressus gigantea* Forest Formation. Distribution altitude: 3000-3200m. It has a narrow distribution range and is mainly found on shady slopes, with a community coverage of 20%.

III: *Pinus armandii +Picea likiangensis* var. *linzhiensis* Forest Formation. Distribution altitude: 2600-3000m. It has a narrow distribution range and is mainly found on shady slopes and semi-shady slopes, with a community coverage of 55%.

IV: *Juniperus tibetica-Berberis temolaica* Forest Formation. Distribution altitude: 3200-4000m. It has a narrow distribution range and is mainly found on shady slopes and semi-shady slopes, with a community coverage of 60%.

V: *Pinus densata +Quercus aquifolioides* Forest Formation. Distribution altitude: 3100-4200m. It has a wide distribution range and can be found on shady slopes, sunny slopes, and semi-sunny slopes, with a community coverage of 80%.

VI: *likiangensis* var. *linzhiensis* Forest Formation. Distribution altitude: 3600-3700 m. It has a narrow distribution range and is mainly found on sunny slopes, with a community coverage of 65%.

VII: *Betula utilis +likiangensis* var. *linzhiensis* Forest Formation. Distribution altitude: 3600-4000m. It has a wide distribution range and is mainly found on semi-shady slopes and shady slopes, with a community coverage of 65%.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

VIII: *Abies georgei* var. *smithii +likiangensis* var. *linzhiensis* Forest Formation. Distribution altitude: 3500-4400 m. It has a wide distribution range and is mainly found on sunny slopes, with a community coverage of 55%.

IX: *Abies georgei* var. *smithii* Forest Formation. Distribution altitude: 4000-4400 m. It has a wide distribution range and is mainly found on sunny slopes and semi-sunny slopes, with a community coverage of 65%.

X: *Tsuga dumosa +Rhododendron nyingchiense* Forest Formation. Distribution altitude: 2500-2600 m. It has a narrow distribution range and is mainly found on semi-shady slopes and semi-sunny slopes, with a community coverage of 80%.

XI: *Larix griffithii +Pinus armandii* Forest Formation. Distribution altitude: 3000 m. It has a narrow distribution range and is mainly found on shady slopes, with a community coverage of 80%.

XII: *Pinus densata+Pinus armandii-Rhododendron nyingchiense* Forest Formation. Distribution altitude: 2500-3000 m. It has a wide distribution range and is mainly found on shady slopes, with a community coverage of 60%.

XIII: *likiangensis* var. *linzhiensis +Abies georgei* var. *smithii -Lonicera hispida* Forest Formation. Distribution altitude: 3300-3700 m. It has a wide distribution range and is mainly found on shady slopes, with a community coverage of 75%.

XIV: *Hippophae rhamnoides subsp. yunnanensis Rousi* Forest Formation. Distribution altitude: 2300-3000 m. It has a wide distribution range and is mainly found on shady slopes and semi-shady slopes, with a community coverage of 60%.

XV: *Pinus densata +Pinus armandii* Forest Formation. Distribution altitude: 2500-2800 m. It has a wide distribution range and is mainly found on shady slopes and semi-shady slopes, with a community coverage of 70%.

XVI: *Pinus densata* Forest Formation. Distribution altitude: 2000-3000 m. It has a wide distribution range and is mainly found on semi-sunny slopes and semi-shady slopes, with a community coverage of 65%.

XVII: *Populus davidiana* Forest Formation. Distribution altitude: 3200 m. It has a narrow distribution range and is mainly found on semi-sunny slopes, with a community coverage of 70%.

XVIII: *Populus szechuanica* var. *tibetica* Forest Formation. Distribution altitude: 2200 m. It has a narrow distribution range and is mainly found on shady slopes, with a community coverage of 70%.

Unclassified: *Alnus nepalensis* Forest Formation. Distribution altitude: 2000-3000 m. It has a wide distribution range and is mainly found on shady slopes, with a community coverage of 70%. It was likely excluded from the TWINSPAN classification due to significantly different growth environments compared to other formations.

DCA ordination analysis of sample plots

DCA was used to ordinate 103 sample plots in the study area, and the results are shown in *Figure 4*. The eigenvalues of the first four ordination axes were 0.620, 0.387, 0.174, and 0.157, respectively. The position of population types in the DCA two-dimensional plot reflects, to some extent, the hierarchical evolution and trends of plant populations within the spatial context. The first two axes in DCA have relatively large eigenvalues, indicating that they contain the most ecological information and can accurately represent the interrelationships among vegetation communities and major ecological populations and environmental factors. Therefore, they have significant ecological value. From the ordination plot, it can be observed that the vegetation community types indicated by the

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

TWINSPAN sorting results have distinct divisions and boundaries in the two-dimensional ordination plot. This indicates that the DCA ordination plot effectively demonstrates the relative correlation between sample plots and their surrounding environments. Analyzing the ordination axes, the first axis primarily reflects the gradient of average elevation, with vegetation communities gradually decreasing from left to right. The second axis primarily reflects the variation of average slope surface, with a change in aspect from shady slopes to sunny slopes from bottom to top along the second axis. Therefore, the DCA two-dimensional ordination curve of the sample points reveals the spatial gradient changes in plant population structure and its relationship with the surrounding natural environment, which is consistent with the TWINSPAN sorting results.

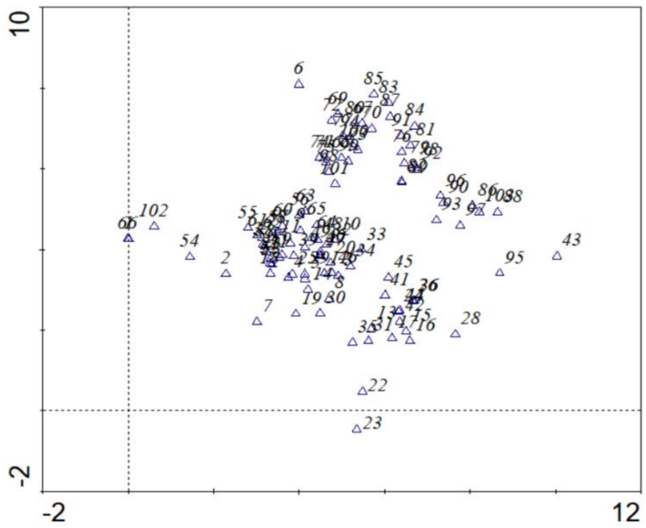

Figure 4. *2D Sorting map of DCA in the Linzhi area of southeast Tibet*

CCA ordination of sample plots

In order to further investigate the distribution of plant communities and the interrelationships with major environmental factors, canonical correspondence analysis (CCA) was performed on 103 vegetation plots and six key environmental factors. The conclusions are shown in *Figure 5*. Along the first axis of the CCA ordination plot, as elevation increases, vegetation communities transition from the *Tibetan Populus szechuanica* var. *tibetica* and *Pinus densata* Forest Formations found at lower elevations to the *Picea likiangensis* var. *linzhiensis* + *Abies georgei* var. *smithii* Forest Formation and *Juniperus tibetica* Forest Formation found at higher elevations in the Lijiang area. The first axis on the ordination plot represents the influence of elevation and slope on the distribution and structure of plant communities. Along the second axis of the ordination plot, there are differences in community distribution associated with changes in slope aspect. The sorting results show that elevation and slope aspect are the primary environmental factors influencing community distribution, followed by slope gradient. Additionally, it can be observed from the ordination plot that the 18 vegetation community types identified by TWINSPAN also have their corresponding distribution ranges and boundaries in the CCA ordination, providing further evidence of the accuracy of the TWINSPAN classification results and its consistency with the CCA ordination of the sample plots.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

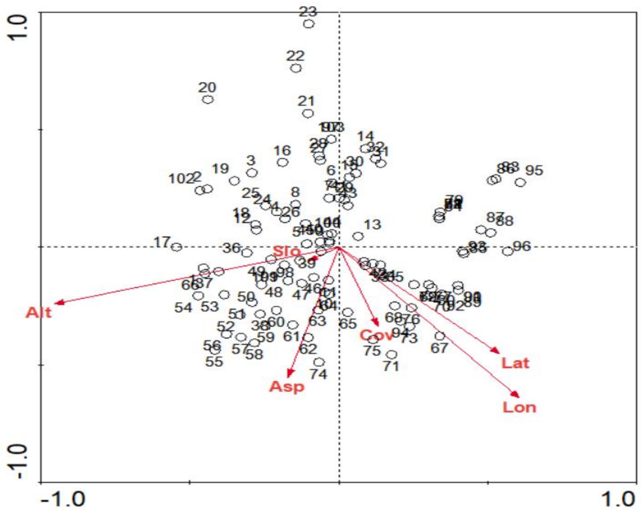

***Figure 5.** CCA two-dimensional sorting map of sample plots in the Linzhi area of southeastern Tibet*

Conclusion

The TWINSPAN classification divided the forest communities in the Linzhi area of southeastern Tibet into 18 vegetation types: *Abies georgei* var. *smithii* Forest Formation, *Juniperus tibetica* Forest Formation, *Picea likiangensis* var. *linzhiensis* + *Abies georgei* var. *smithii* Forest Formation, *Taxus wallichiana- Rhododendron nivale* Forest Formation, *Pinus densata* + *Quercus franchetii* var. *forrestii* Forest Formation, *Juniperus tibetica* Forest Formation, *Betula utilis* + *Juniperus tibetica* Forest Formation, *Picea likiangensis* var. *linzhiensis* + *Juniperus tibetica* Forest Formation, *Picea likiangensis* var. *linzhiensis* Forest Formation, *Taxus yunnanensis- Rhododendron nivale* Forest Formation, *Picea likiangensis* var. *linzhiensis* + *Pinus densata* Forest Formation, *Pinus densata* + *Picea likiangensis* var. *linzhiensis - Lonicera incurvata* Forest Formation, *Hippophae rhamnoides* Forest Formation, *Pinus densata* + *Picea likiangensis* var. *linzhiensis* Forest Formation, *Pinus densata* Forest Formation, *Pinus densata* + *Pinus densata* Forest Formation, *Pinus densata* Forest Formation, *Populus szechuanica* var. *tibetica* Forest Formation, and *Populus szechuanica* var. *tibetica* + *Quercus franchetii* var. *forrestii* Forest Formation. The first axis of the DCA ordination primarily reflects the gradient of elevation, while the second axis reflects changes in slope aspect. Each vegetation community identified by TWINSPAN in the DCA ordination plot has its own distribution range and boundaries, indicating that DCA ordination effectively reflects the relationship between vegetation communities and their environmental resources. Additionally, the sorting results of TWINSPAN are well supported by the ordination plot. The DCA ordination of the sample plots indicates that elevation is the primary environmental factor influencing community distribution, followed by slope aspect. CCA ordination further elucidates that forest community distribution in the Linzhi area of southeastern Tibet is determined by environmental factors such as elevation and slope aspect, indirectly validating the results of the TWINSPAN classification.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

Discussion

The classification results of this study to some extent reflect the gradient differences in habitat conditions and the coordinated relationship between biota and the natural environment. Additionally, due to the localized and specific habitat conditions present in the study area, specific vegetation types, such as the *Hippophae rhamnoides* Forest Formation, appear in the classification results. These specific formations are displayed on the ordination plot, exhibiting distinct separation from other vegetation types or communities, indicating their specific habitat requirements. Furthermore, the results of the classification show discontinuity in terms of location, with many populations located far apart being assigned to the same vegetation type. This may be related to the small-scale climatic conditions generated by the complex geological environment in southeastern Tibet.

Ecologists believe that community formation is influenced by a combination of climate, topography, and soil factors. At larger regional scales, climate conditions (water and thermal conditions) are the dominant environmental factors influencing community distribution. At the community and landscape scales, non-zonal environmental factors (such as topography and soil nutrients) dominate the distribution patterns of communities (Xu et al., 2007; Van et al., 2010). Due to the complex topography and climate conditions in the study area, there are significant differences in habitat conditions. Compared to studies conducted on vegetation in the Lhasa River Valley, which is also located on the Tibetan Plateau and where vegetation distribution is mainly influenced by elevation and moisture (Yang et al., 2010), the distribution of forest communities in this study area is primarily affected by elevation and slope aspect, followed by slope gradient. This finding is consistent with the results of previous studies by Wang et al. (2019) in the Yarlung Zangbo River area and Wang and Yang (2016, 2011) in the Lijiang area.

This study also found that the effect of slope gradient on forest population abundance is not clear, which may be due to differences in the study area and the scale of the research. It could also be related to the unique climatic conditions in the Linzhi area of southeastern Tibet, where slope gradient may not have a significant impact on community formation.

In conclusion, this study applied TWINSPAN classification, DCA, and CCA ordination to investigate the distribution of forest populations in the Linzhi area of southeastern Tibet, providing valuable insights and patterns of distribution for plant communities and key ecological factors. These findings can serve as a theoretical basis for forest conservation, development, and related plant community surveys in the southeastern Tibetan region.

REFERENCES

[1] Abbas, A. M., Ayed, F. A. A., Sheded, M. G., Alrumman, S. A., Radwan, T. A. A., Badry, M. O. (2021): Vegetation Analysis and Environmental Relationships of Riverain Plants in the Aswan Reservoir, Egypt. – Plants 10(12): 2712.

[2] Hatim, M. Z., Janssen, J. A. M., Pätsch, R., Shaltout, K., Schaminée, J. H. J. (2021): Phytosociological survey of the desert vegetation of Sinai, Egypt. – Applied Vegetation Science 24(4): e12627.

[3] Hill, M O. (1979): TWINSPAN: A FORTRAN program for arranging multivariable data in an ordered two-way table classification of the individuals and attributes. – In: Section of Ecology and Systematica, Cornell University.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2303_49114920

[4] Lysenko, H. M., Danylyk, I. M., Iemelianova, S. M., Borsukevych, L. M., Sosnovska, S. V. (2021): Comparative assessment of Western Podolia meadow steppes (Ukraine) based on the synphytoindication method. – Hacquetia 20(1).
[5] Rahman, I. U., Afzal, A., Iqbal, Z., Bussmann, R. W., Alsamadany, H., Calixto, E. S., Shah, G. M., Kausar, R., Shah, M., Ali, N., Ijaz, F. (2020): Ecological gradients hosting plant communities in Himalayan subalpine pastures: Application of multivariate approaches to identify indicator species. – Ecological Informatics 60: 101162.
[6] Ren, Q. S., Yang, X. L., Cui, G. F., Wang, J. S., Huang, Y., Wei, X. H., Li, Q. L. (2007): Smithfir formation structure and dynamics in the timberline ectone of the Sejila Mountain, Tibet, China. – Acta Ecologica Sinica 27(7): 2669-2677.
[7] Su, R. G., Zhang, J. T., Zhang, B., Cheng, J. J., Tian, S. G., Zhang, Q. D., Liu, S. J. (2010): Quantitative classification and ranking of forest communities in Songshan Nature Reserve. – Journal of Ecology 30(10): 2621-2629.
[8] Van Couwenberghe, R., Collet, C., Lacombe, E., Pierrat, J. C., Gégout, J. C. (2010): Gap partitioning among temperate tree species across a regional soil gradient in windstorm-disturbed forests. – Forest Ecology and Management 260(1): 146-154.
[9] Wang, J. S., Li, W. H., Ren, Q. S., Liu, M. C. (2007): The Value of Forest Ecosystem Services in Tibet. – Journal of Natural Resources 22(5): 831-841.
[10] Wang, Y. S., Shangguan, T. L. (2010): Some problems on the calculation method of important values. – Journal of Shanxi University (Natural Science Edition) 33(2): 312-316. DOI: 10.13451.
[11] Wang, J. S., Yao, S. C., Pu, Q., Wang, Z. K., Feng, J. G. (2016): Quantitative classification and ordination of grassland communities in the Changtang. – Journal of Ecology 36(21): 6889-6896.
[12] Wang, T., Wang, J. S., Ding, Y., Liu, W. J., Bao, X. T., Li, C. (2019): Quantitative Classification and Ordination of Plant Communities in the Upper and Middle Reaches of the Yarlung Zangbo River Basin. – Journal of Resources and Ecology 10(4): 389-396.
[13] Wu, H., Zhang, J. L., Fan, Y. W., Yu, L. F., Yan, L. B., Yuan, C. J. (2013): Quantitative classification and ordination of plant community structure in Caohai watershed. – Journal of Nanjing Forestry University (Natural Science Edition) 37(3): 47-52.
[14] Xu, G. C., Kang, M. Y., Ma, M., Liu, Q. R., Zhu, Y., Wang, H., Guo, W. W., Xu, D., (2007): The relationship between herbaceous vegetation and the environment in the middle reaches of the Halaqin Gully Basin in Daqing Mountain, Inner Mongolia. – Journal of Mountainous Science 4: 393-399.
[15] Yang, W. F., Zhang, G. J., Zhang, Y. Q., Sun, Z. B. (2006): Ecological tourism resources and their development and utilization in southeastern Tibet. – Forestry Survey and Planning 6: 120-124.
[16] Yang, X. L., Zhao, K. T., Ma, H. P., Lu, S. H., Luo, J. (2010): Ecological study on vegetation quantity in semi-arid river valleys of Lhasa. – Forestry Science 46(10): 15-22.
[17] Yang, X. L., Wang, J. S., Chen, B. X., Pu, Q. (2011): Quantitative characteristics of forest line vegetation communities in Sejila Mountain, Tibet. – Journal of Beijing Forestry University 33(3): 45-50. DOI: 10.13332/j.1000-1522.2011.03.001.
[18] You, J., Feng, J. M. (2013): The floristic composition and Species diversity of Spermatophyte in Southeast Tibet. – Journal of Ecological Environment 22(2): 207-212.
[19] Zhang, J. T. (2011): Quantitative Ecology. – Beijing: Science Press, pp. 184-247.