

Diversity Relationship of Epilithic Bryophytes in the Rocky Desertification Area of Huajiang, Guizhou

Min Gao^{1,2}, Xiaona Li^{1,2,*}

¹ School of Karst Science, Guizhou Normal University, Guiyang, Guizhou, China

² State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University, Guiyang, Guizhou, China

Abstract

In this paper, a total of 178 samples were collected for sampling and analysis of the rock surface mosses on both sides of the Huajiang Grand Canyon in the Huajiang rocky desertification area, and the results showed that there were 9 families, 12 genera and 20 species in the Huajiang rocky desertification research area, and the largest number of genera was the grey moss and the cluster moss, and the dominant family was Entodontaceae Kindb. and pottiaceae Hampe, the dominant species is *Erythrodonium julaceum* (Schwägr.) Paris accounted for 28.57%. In comparison between the two banks of the canyon, the species diversity on the south bank of the Huajiang River is higher than that of the north shore. The Epilithic Bryophytes on the surface of the study area are mainly interwoven types that are easy to peel off, supplemented by the cluster type, which shows the selective adaptability of bryophytes to the environment in the Huajiang Rocky desertification research area.

Keywords

Rocky Desertification; Epilithic Bryophytes; Diversity Relationship.

1. Introduction

Bryophytes are one of the pioneer plants and play an important role in the forward succession of degraded ecosystems (Cheng et al. 2020). Bryophytes, including mosses, liverworts, and bryophytes, are the second continental plant group after seed plants. There are more than 23,000 species of bryophytes worldwide, accounting for about 5% of the total plants (Li and Zhang 2014) Bryophytes are ideal materials for studying the impact of environmental changes on species ecology and evolution. They have four outstanding characteristics. Firstly, the distribution range of moss is extremely wide, in addition to the wet growth of suitable plants, in the desert, rocky desert, polar, alpine and other vascular plants are difficult to survive in the harsh habitat can also be seen in the moss plant; Secondly, mosses are simple in structure and lack true roots and vascular bundles (Wu, Cheng, and Gao 2003), mainly through plant stems and leaves. The surface absorbs water and nutrients. Thirdly, the vitality of mosses is extremely tenacious, and its adaptability to harsh environments such as drought, high temperature, and severe cold is much higher than that of vascular plants. Fourthly, Fourth, compared with woody plants, bryophytes have shorter generational rotation times and are more likely to show adaptive strategies for environmental changes. These four characteristics make bryophytes play an important ecological role in CO₂ fixation, soil and water conservation, water conservation, material circulation, and forest regeneration, and are an integral part of the ecosystem that cannot be ignored. For a long time, scholars have done a lot of research on the prevention and control of rocky desertification in karst areas, and some of them have paid attention to the importance of bryophyte research in the improvement of the karst rocky

desertification environment (Cheng et al. 2019, Cao et al. 2020). The study of bryophytes in rocky desertification areas is of great significance to the research on vegetation succession and ecological restoration of rocky desertification ecosystems (Liu, Shen, and Zhang 2018).

2. Overview of the Study Area

The Guanling-Zhenfeng Rocky Desertification Control Huajiang Comprehensive Demonstration Area in the study area is located in the Huajiang section of the Beipanjiang Grand Canyon (25°37'40"-25°42'30"N, 105°35'00"-105°43'20"), known as the Huajiang Grand Canyon. The canyon is located on the large gentle slope of the Yunnan-Guizhou Plateau facing the Beipan River, mainly in the valleys and depressions of Fengcong, with an altitude of 450-1450 m (Sheng et al. 2015), which is a typical karst medium-strength rocky desert. The soil is dominated by loess loam and purple sand soil (Sui et al. 2010), with poor soil water-holding capacity and serious soil erosion.

3. Research Method

In January 2021, a preliminary investigation on the growth of moss on roads and rock surfaces was carried out in the study area. In April and September 2021, the lithophytes in the comprehensive demonstration area of Guanling-Zhenfeng rocky desertification control Huajiang River were investigated twice. The acquisition was performed (Figure 2-2). The sampling sites are distributed on both sides of the Huajiang Grand Canyon, and the slope is generally above 60 ° (Yang and Long 2005), involving the side of Guanling Buyi and Miao Autonomous County of Anshun City on the north bank and the side of Zhenfeng County of Southwest Guizhou Buyi and Miao Autonomous Prefecture. The samples were collected mainly along the S210 provincial highway, village roads, and villager grazing paths on both sides of the canyon. During sampling, the straight-line distance between each sampling point was guaranteed to be no less than 20m. A total of 178 specimens were collected.

Before sampling begins, take pictures of the microhabitat and macroenvironment at the sampling site. After sampling, use a kraft paper bag to pack the samples and bring them back to the station, and place them in a ventilated indoor place to dry in the shade; for samples with high water content, it is necessary to spread out to absorb the moisture and then dry in the shade to prevent the samples from being damp, rotten and moldy.

Species identification uses classical morphological classification methods, and tools such as Olympus microscopes (SZX-16, BX-53) are used to observe the life form, plant height, leaf shape, whether the leaves are fragile, leaf edge shape, etc. under the microscope. The key morphological characteristics such as leaf tip shape, wart, number of middle ribs, leaf base cell characters, number of capsule teeth, etc., were identified and recorded with reference to Bryophyta and other research paper such as Moss Flora of China and Moss Flora of Guizhou.

4. Results and Analysis

4.1. Species Composition of Epilithic Bryophytes

The Huajiang rocky desertification area, where the study area is located, is a typical rocky desertification area. It has the characteristics of dry and hot rocky desertification areas, and the poor water and heat conditions on the rock surface lead to the low species richness of lithophytes. According to statistics, there are 20 species of 9 families, 12 genera, and 20 species of rock surface mosses in the Huajiang rocky desertification area (Table 1, Table 2). Among them, there are 8 families, 11 genus and 19 species of mosses, and 1 family, 1 genus, and 1 species of liverworts. The largest genera in the study area are Cryoptera and Pseudomonas,

accounting for 90 %, of which *Crypsopsis* has 5 families, 7 genera, and 10 species, and *Pseudomonas* has 2 families, 4 genera and 8 species.

On the north bank of the canyon, there are 3 orders, 7 families, 10 genera, and 12 species of bryophytes; on the south bank of the canyon, there are 17 species of 4 orders, 8 families, 11 genera, and 17 species. *Pseudomonas* has an absolute dominance on both sides of the strait, and *Pseudomonas* is also more distributed in the southern bank.

Table 1. The number of epilithic bryophytes in Huajiang Area

Class	Order	Family	Genus	Species
		N	N	N
		S	S	S
Bryopsida Rothm.	Pottiales M. Fleisch.	2	4	8
		1	3	4
		2	4	7
	Hypnobryales W.R.Buck&Vitt	5	7	10
		5	5	7
		4	5	8
	Eubryales	1	1	1
		1	1	0
		1	1	1
Hepaticae	Jungermanniales H. Klinggr.	1	1	1
		0	0	0
		1	1	1
Total	4	9	12	20
	3	7	10	12
	4	8	11	17

Table 2. The list of epilithic bryophytes in Huajiang River Grand Canyon

Family	Genus	Species	
Pottiaceae Hampe	Trichostomum Bruch	Trichostomum crispulum Bruch	
		Trichostomum brachydontium Bruch	
		Trichostomum sinochenii Redf. & B. C. Tan	
	Barbula Hedw	Barbula unguiculata Hedw.	
		Barbula indica (Hook.) Spreng.	
	Hyophila Brid.	Hyophila javanica (Nees & Blume) Brid.	
		Hyophila involuta (Hook)	
Ptychomitriaceae Schimp.	Ptychomitrium Fürnr.	Ptychomitrium gardneri Lesq.	
Entodontaceae Kindb.	Erythrodonium Hampe	Erythrodonium julaceum (Schwägr.) Paris	
		Entodon Müll. Hal.	Entodon prorepens (Mitt.) A. Jaeger
			Entodon cladorrhizans (Hedw.) Müll. Hal.
		Entodon challengerii (Paris) Cardot	
Amblystegiaceae G. Roth	Platydictya Berk.	Platydictya jungermannioides (Brid.) Crum	
Anomodontaceae Kindb.	Anomodon Hook. & Taylor	Anomodon viticulosus (Hedw.) Hook. & Taylor	
		Anomodon minor Lindb.	
Brachytheciaceae Schimp.	Brachythecium Schimp.	Brachythecium garovaglioides Müll. Hal.	
		Homalothecium Schimp.	Homalothecium leucodonticaule (Müll. Hal.) Broth.
Thuidiaceae Schimp.	Thuidium Bruch & Schimp.	Thuidium cymbifolium (Dozy & Molck.) Dozy & Molck.	
Mniaceae Schwägr.	Plagiomnium T. J. Kop.	Plagiomnium integrum T. J. Kop.	
Frullaniaceae Lorch	Frullania Raddi	Frullania muscicola Steph.	

4.2. Statistics of Dominant Taxa of Epilithic Bryophytes

Dominant species refers to the species with the largest proportion of vegetation or plant community in the region. Statistics and analysis of the number and characteristics of dominant families and species can help us understand the community structure, species richness, and flora relationship in the region. Ecological research in this area plays an important role. In this karst area, this study counted species with an occurrence frequency greater than 4.5% as dominant species and analyzed the altitude and distribution of dominant species on both sides of the river.

Statistics and analysis of 9 families, 12 genera, and 20 species of bryophytes in the Huajiang rocky desertification area (Table 2) found that there are 8 dominant species of Lithophyte bryophytes in the study area, belonging to 4 families and 6 genera (Table 3, Figure 1), which can reflect the distribution of species in the area.

Table 3. The list of the dominant epilithic bryophytes in Huajiang

Family	Genus	Species	Altitude range (m)
Pottiaceae Hampe	Trichostomum Bruch	Trichostomum brachydontium Bruch	500-900
		Trichostomum crispulum Bruch	400-1000
	Hyophila Brid.	Hyophila javanica (Nees & Blume) Brid.	900-1000
	Erythrodontium Hampe	Erythrodontium julaceum (Schwägr.) Paris	400-1400
Entodontaceae Kindb.	Entodon Müll. Hal.	Entodon cladorrhizans (Hedw.) Müll. Hal.	500-800
		Platydictya Berk.	Platydictya jungermannioides (Brid.) Crum
Amblystegiaceae G. Roth	Anomodon Hook. & Taylor	Anomodon viticulosus (Hedw.) Hook. & Taylor	500-1000
Anomodontaceae Kindb.		Anomodon minor Lindb.	400-1200

Figure 1(a) and table 3 show that the species of mosses grown at different altitudes are different: in the low altitude area below 800 meters, there are mainly Trichostomum Bruch, Erythrodontium Hampe, Entodon Müll. Hal, Platydictya Berk., and Anomodon Hook. & Taylor; in areas above 800 meters above sea level, there are mainly Trichostomum Bruch, Erythrodontium Genus Erythrodontium Hampe, and Anomodon Hook. & Taylor. In the comparison of common lithophytic bryophytes on the north and south banks, the north bank is larger than the south bank, and the species diversity of the north bank is lower than that of the south bank. As shown in Figure 1(b) there are seven common genera at the genus level, Erythrodontium Hampe) accounted for the highest proportion at 28.57 %, followed by Anomodon Hook. & Taylor, accounting for 15.87 % respectively. Lithophyte mosses are the predominant species in both genera. As shown in Figure 1(c), at the species level, there are 8 species of mosses, accounting for 76.19 % of all samples. Erythrodontium julaceum (Schwägr.) Paris was the absolute dominant species, accounting for 28.57 %; Anomodon minor Lindb. and Platydictya jungermannioides (Brid.) Crum followed with 9.52 % each; in addition, Entodon cladorrhizans (Hedw.) Müll. Hal., Hyophila javanica (Nees & Blume) Brid. and Anomodon viticulosus (Hedw.) Hook. & Taylor each accounted for 6.35 %. Erythrodontium julaceum (Schwägr.) Paris is one of

the most common mosses on the karst calcareous carbonate rocks in Guizhou with a mossy species with good drought tolerance. The large-scale distribution of it is the embodiment of the survival advantage of the drought-tolerant species of moss in the harsh environment of the rock surface. *Platydictya jungermannioides* (Brid.) Crum prefers to live in a calcareous and moist environment, often growing on the shady side of rocks. These dominant species reflect the characteristics of the species in the karst rocky desertification area, which are calcium-loving and drought-tolerant.

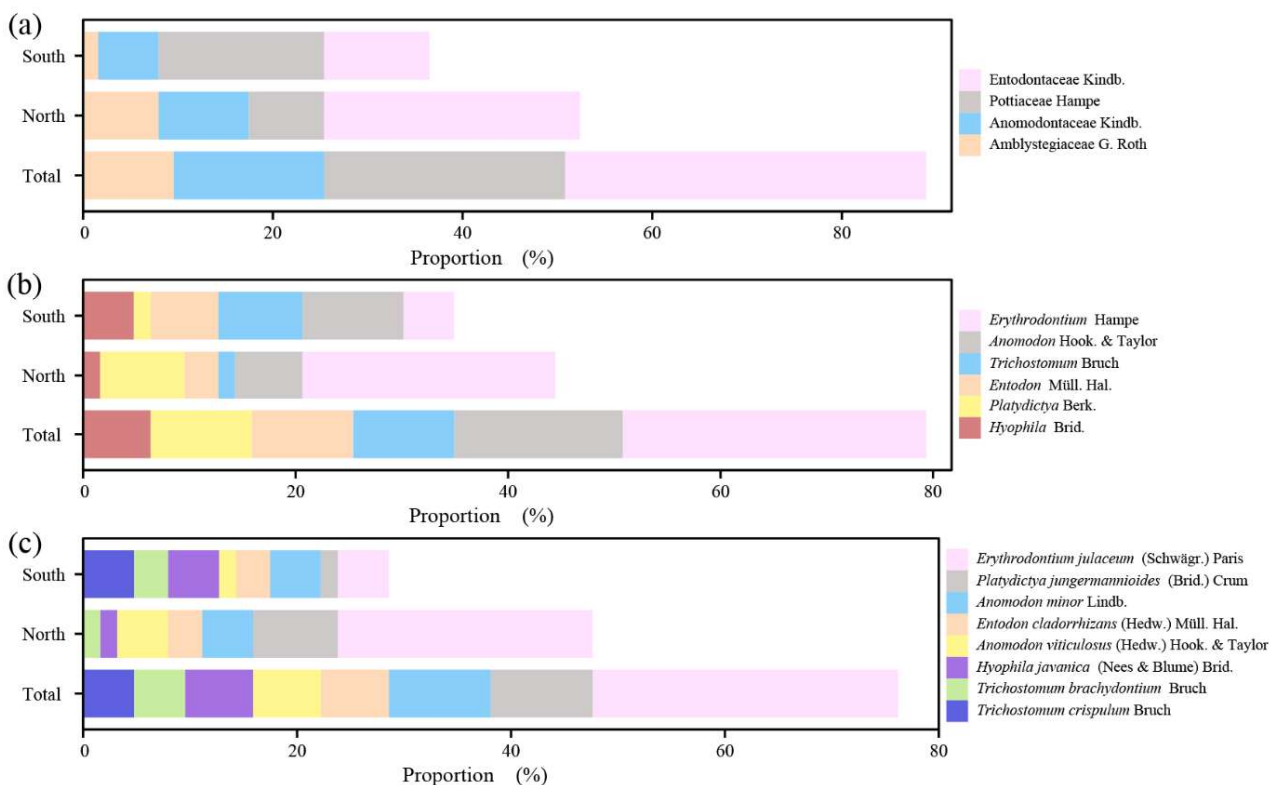


Figure 1. The distribution of dominant families, genera and species of the epilithic bryophytes in Huajiang Area

4.3. Life form Analysis of Lithophytic Bryophytes

According to Madgefrau Karl (1982) made a statistical analysis of the life forms of epilithic bryophytes in the Huajiang rocky desertification area, and found that there are two types of bryophytes in the study area: cluster type and interweaving type, and the number of species is 8 and 8. 12 kinds (Figure 2).

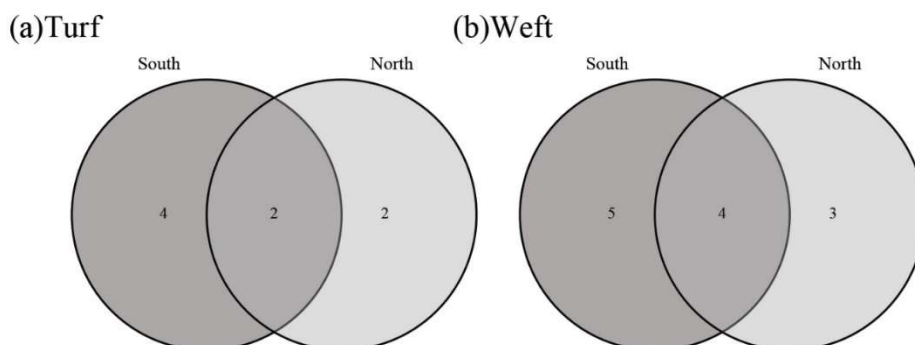


Figure 2. The distribution of life forms of the epilithic bryophytes in Huajiang River Grand Canyon

(1) Turf

The main stem of the cluster-type moss is erect or tilted, with few branches, easy to peel off from the substrate, and often occupies a large area. There are 8 species of cluster moss in the study area, accounting for 40 % of the total species; 6 species of cluster moss (accounting for 30 %) on the south bank and 4 species (20 %) on the north bank. The common taxa on both sides of the strait are *Trichostomum* Bruch and *Hyophila* Brid.

(2) Weft

The plant body is creeping, similar in shape to the flat type (Mats), the flat type plant body is densely creeping, the main stem grows horizontally along the substrate, the branches are fixed on the substrate, and it is closely attached to the growth substrate and is not easy to peel off; the intertwined plants are intertwined with each other, But it is sparsely attached to the substrate and easy to peel off. There are 12 species of interwoven moss in the study area, accounting for 60% of the total; 9 species of interwoven moss (45%) on the south bank and 7 species on the north bank (35%). The common moss species on both sides of the strait are *Entodon* Müll. Hal., *Anomodon* Hook. & Taylor and *Erythrodon* Hampe.

The life forms of mosses on the rock surface in the Huajiang rocky desertification area are only interwoven and clustered, and no fan-shaped, tree-shaped, and other life forms are found, which reflects the high inhibition of moss growth by the rock surface environment and limits the moss with weak drought tolerance. grow.

Epilithic bryophytes of the study area are mainly wefts. It is sparsely attached to limestone in a large area, and the cleavage between false roots and matrix is not obvious, and it is easy to peel off. There are more species of wefts mosses than turfs mosses. The intertwined moss plants are intertwined with each other, and the stolons are several centimeters long. Large-scale tiling is conducive to intercepting rainwater and soil particles, accelerating soil consolidation and water retention, improving the local niche on the rock surface, and enabling the community to develop better. A virtuous circle. The main stem of the cluster moss is upright and densely clustered, and the plants are closely connected by false roots to form a rock surface crust. During rainfall, the rainwater can be quickly intercepted on the exposed rock surface, and the gaps between the plants can store a large flow of water; With the thickening of the moss crust, the originally dry and high-temperature rock surface environment became humid, which provided the basic conditions for the colonization of other plants to a certain extent, and played the pioneering role of bryophytes. Therefore, the choice of life forms of rock-surface bryophytes in karst habitats in the study area reflects the adaptive strategies of bryophytes to the environment.

5. Conclusion

Differences in environmental factors lead to differences in moss species composition at different scale habitats. In this study, a total of 9 families, 12 genera and 20 species of Lithophytum are collected in the Huajiang rocky desertification area, including 7 families, 10 genera, and 12 species in the north bank of the canyon, and 8 families, 11 genera, and 17 species in the south bank. The dominant family of stone bryophytes in the area is Pottiaceae. Hampe and Entodontaceae Kindb., the most dominant species is *Erythrodon* julaceum (Schwägr.) Paris. In the comparison between the two sides of the canyon, the species diversity on the south bank of the Huajiang River is higher than that on the north bank. Lithophytic bryophytes in the study area are mainly classified into two types: cluster type and interweaving type. It is mainly based on the interwoven type that is easy to peel off. It is sparsely attached to limestone in large areas to intercept rainwater and soil particles, accelerate soil retention, and improve the local small habitat of the rock surface. The main stem of the cluster moss in the study area was erect and densely clustered, and the plants were short and mainly patches. This research is part of

the background investigation of rock surface bryophytes in rocky desertification areas, which can provide basic data for rocky desertification ecological process research, and provide scientific support for further theoretical research on rocky desertification ecosystem vegetation restoration.

References

- [1] Cao, Wei et al. 2020. 'Bryophytes and the Symbiotic Microorganisms, the Pioneers of Vegetation Restoration in Karst Rocky Desertification Areas in Southwestern China'. *Applied Microbiology and Biotechnology* 104(2): 873–91.
- [2] Cheng, Cai et al. 2020. 'Moss Biocrusts Buffer the Negative Effects of Karst Rocky Desertification on Soil Properties and Soil Microbial Richness'. *Plant and Soil* (prepublish).
- [3] Cheng, Cai, Yujie Li, Mingzhong Long, and Xiaona Li. 2019. 'Application Potential of Soil Crust on the Control of Karst Rocky Desertification'. *Chinese Journal of Applied Ecology* 30(7): 2501–10.
- [4] Li, Xiaopeng, and Xingang Zhang. 2014. 'Brief Description of the Current Situation of Bryophyte Research in China'. *South China Agriculture* 8(18): 152–54.
- [5] Liu, Run, Jiachen Shen, and Zhaohui Zhang. 2018. 'Study on Significance of Ecological Restoration of Four Bryophytes in Karst Rocky Desertification Area'. *Journal of Soil and Water Conservation* 32(6): 141–48.
- [6] Magdefrau, Karl. 1982. London:Chapmanand Hall Bryophyte Ecology.
- [7] Sheng, Maoyin, Kangning Xiong, Gaoyang Cui, and Yang Liu. 2015. 'Plant Diversity and Soil Physical-Chemical Properties in Karst Rocky Desertification Ecosystem of Guizhou'. *Acta Ecologica Sinica* 35(2): 434–48.
- [8] Sui, Zhe et al. 2010. 'Integrated Study on Ecological Engineering Technology for Comprehensive Management of Rocky Desertification at Different Levels in Karst Small Watersheds'. *Soil and Water Conservation in China* 4: 17–19.
- [9] Wu, Yuhuan, Guodong Cheng, and Qian Gao. 2003. 'Bryophyte's Ecology Functions and Its Significances in Revegetation'. *Journal of Desert Research* (03): 9–14.
- [10] Yang, Jie, and Mingzhong Long. 2005. 'Preliminary Estmiation and Analysis on Economic Losses Caused by Soil Erosion in Karst Gorge Area--The Demonstration Area of Huajiang as an Example'. *Journal of Guizhou Normal University (Natural Sciences)* 23(4): 13–17.