CHARACTERISTICS AND DIVERSITY OF MAIN SHRUB COMMUNITIES IN SOUTHEAST TIBET

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Abstract. This study investigates the changing laws of species composition, community composition and species diversity of typical shrubs in southeastern Tibet. It selects 12 typical shrub communities distributed in the five counties of Bayi District, Gongbujiangda County, Milin County, Lang County, and Bomi County in Nyingchi City as the research objects to systematically study characteristics and diversity of main shrub communities in southeastern Tibet. The results showed that the shrubs in Nyingchi of southeastern Tibet have diverse herb plants, while bush is relatively simple. Among the 12 shrub communities investigated, there are 230 species of plants, belonging to 49 families and 107 genera. According to statistics, there are more drought-tolerant families of Compositae, Rosaceae, Leguminosae, and Polygonaceae. Compositae accounted for the highest proportion of 13.1% among the surveyed plants, while Solanaceae, Crassulaceae, and Bignoniaceae only accounted for the smallest proportion of 0.5%. On the whole, D diversity index of the surveyed shrub community varied between 0.74~0.98, while H diversity index varied between 1.85~2.96. Different habitat conditions lead to different interlayer structures in community diversity. Except for *Sabina pingii*, *Rhododendron nyingchiense* + *Rhododendron nivale*, *Sophora moorcroftiana* + *Leptodermis forrestii*, Quercus aquifolioides, herb layer in the other shrub communities has greater species diversity than the shrub layer.
Keywords: *southeastern Tibet, shrub community, structural characteristics, species diversity, ecosystem functions*

Introduction

Shrubs constitute an important part of terrestrial ecosystems and play an important role in maintaining the ecosystem balance and protecting species diversity (Guo et al., 2020). Community structure can reflect the basic attributes of plant communities, which provides an important basis for understanding community composition, succession and development (Yue et al., 1999; Jin et al., 2012). Species diversity is an index to measure the stability of community structure and ecological functions. Studying community species diversity can not only reflect differences in community composition, structure, and function, but also reflect the relationship between environmental conditions and communities (Anwar et al., 2018). Research on plant community structure and its species diversity carries great significance for clarifying community renewal, succession and stability characteristics (Yuan et al., 2014). Shrubs play an important role in plant diversity, not only increasing the source of species productivity and improving ecological stability, but also greatly enriching the diversity of plant communities (Li, 2000). Therefore, studying shrub diversity is extremely important. Study area is located in the southeastern part of Tibet, where the unique climate conditions contribute to rich and diverse community types and biodiversity. However, previous studies on vegetation in southeastern Tibet are limited to the Sejila Mountain area, mostly concentrated in the structure function, vertical zonation, flora, forest line vegetation, etc. of the forest ecosystem (Wang et al., 2007; Ren et al., 2007; You et al., 2013; Zhu et al., 2022), and the shrub community ecosystem is not involved. The shrub community in southeastern Tibet

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has an important position and significance in the forest ecosystem of Tibet, which is an important fortress to maintain the ecological security barrier in southeastern and southwestern Tibet, also playing an indispensable role in ecological security. Take the forest ecosystem mainly represented by the Nyingchi area in southeastern Tibet as an example. Systematic investigation and research on the structure characteristics of the typical shrub communities in Nyingchi area is of important significance for clarifying the renewal, succession and stability characteristics of the shrub community in southeastern Tibet, which can provide basic data and scientific basis for the construction of Tibet's ecological security barrier and the protection, advantageous to restoration and construction of the forest ecosystem in southeastern Tibet.

Overview of the study area

This study investigates the Nyingchi area in "southeastern Tibet" (including 5 counties of Bayi, Gongbujiangda, Milin, Langxian, Bomi, etc., *Fig. 1*). Located in the southeast of Tibet, the middle and lower reaches of the Yarlung Zangbo River, it has geographical position at 92°11′~96°40′E, 28°41′~30°53′N, with annual precipitation at about 650 mm, annual average temperature at 8.7 °C, average sunshine duration at 2022 h, and frost-free period of 180 days. With average elevation of 3100 m, it is low in the south and high in the north. Affected by diverse three-dimensional climates, the vertical vegetation zone in the region is complete. From low altitude to high altitude, there are evergreen broad-leaved forests, evergreen and deciduous broad-leaved mixed forests, deciduous broad-leaved forests, coniferous and broad-leaved mixed forests, coniferous forests, shrubs, meadows, grasslands, etc. (Wang et al., 2007). This area has very important research value in the research of vegetation ecosystem (*Fig. 2*).

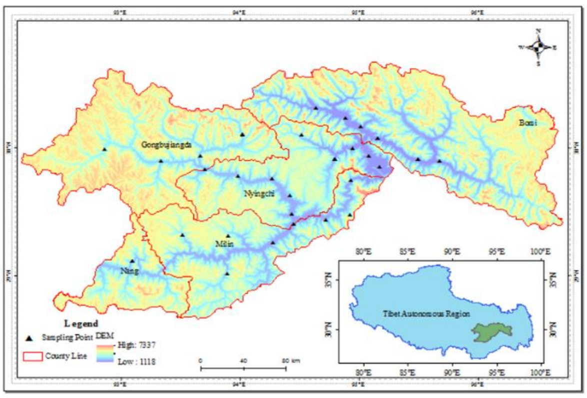

Figure 1. *Study area chart*

Rhododendron nyingchiense | *Quercus aquifolioides* | *Salix oritrepha* + *Rhododendron* sp.

Figure 2. *Photos of shrub communities*

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Research methods

Community survey

In July 2020 and September 2021, through two field surveys, a comparative study was conducted on the shrub communities in southeast Tibet. Using route survey method, we selected one representative sample plot from different shrub communities, described the basic situation of the sample plot, used GPS for positioning, and measured terrain features such as slope, aspect, and slope position (*Table 1*). In each sample plot, nested quadrats were used to collect vegetation species and community structure data. The shrub community plots were set with quadrats of 5 m × 5 m, and there were 4 herb quadrats of 1 m × 1 m. The setting of sample plots should ensure relatively uniform and natural habitat as much as possible so that the quadrats are representative. A total of 29 shrub vegetation plots and 116 herb quadrats were investigated. the plant name, height (Laser altimeter), coverage (It is expressed by the ratio of crown width of the same tree species in the sample plot to the area of the sample plot), number of clusters and total coverage in the quadrat were recorded. Samples of unidentified species were taken to the laboratory for identification.

Table 1. *Plots information table*

Plot number	Altitude /m	Longitude/°	Latitude/°	Slope direction/°	Slope grade/°
1	4710	92.33186111	29.86655833	340	25
2	4360	92.42969722	29.90831111	15	20
3	4310	92.43138889	29.91416667	150	12
4	3980	92.74116667	29.93553611	45	5
5	3460	93.18537778	29.88903889	285	5
6	2970	94.16579444	29.74805556	0	5
7	3100	93.15861111	29.03500000	50	10
8	3840	92.69944444	29.24972222	225	8
9	3160	92.81305556	29.06083333	30	10
10	3700	92.83305556	29.86027778	85	10
11	3420	92.85944444	29.94277778	50	15
12	3100	93.29638889	28.99305556	0	10
13	3011	93.85472222	29.12611111	0	15
14	2940	94.52027778	29.45388889	330	15
15	4300	94.62944444	29.62694444	170	25
16	4400	94.63444444	29.62805556	165	20
17	4500	94.64277778	29.61694444	170	20
18	4600	94.64444444	29.63611111	160	10
19	4650	94.65388889	29.61361111	325	15
20	4600	94.29472222	29.61388889	330	25
21	3370	96.41904722	29.58670833	210	15
22	3375	96.075675	29.99125833	37	15
23	3240	96.09915278	29.80568333	0	10
24	2980	96.01455	29.73977778	330	15
25	3030	95.617525	29.98854722	30	15
26	2910	95.69750278	29.78471111	240	15
27	3779	95.72848056	29.98449444	0	5
28	3776	95.562325	29.87218056	0	25
29	2760	95.01740833	30.13985833	340	20

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Data calculation

(1) Importance value calculation

Based on the statistics of the species height, coverage, frequency, etc. in each quadrat, the importance value of the species is calculated with reference to the following formula (Greig, 1983): Importance value = (relative frequency + relative density + relative coverage)/3.

(2) Species diversity index

Considering the ability of the species diversity index in reflecting the community biodiversity status and its wide application, this paper selected Shannon-Wiener index (H), Pielou evenness index (J), Simpson index (D), Simpson dominance index (C) to measure the species diversity of the shrub community. The calculation formula is as follows:

$$\text{Simpson diversity index (D): } D = \sum_{i=1}^{s} N_i^2 \quad \text{(Eq.1)}$$

$$\text{Shannon-Wiener diversity index (H): } H = -\sum_{i=1}^{s} N_i x \ln N_i \quad \text{(Eq.2)}$$

$$\text{Pielou evenness index (J): } J = Jsw = H / \ln S \quad \text{(Eq.3)}$$

$$\text{Simpson dominance index (C): } C = \sum_{i=1}^{s} N_i^2 \quad \text{(Eq.4)}$$

where: S is the number of species in the quadrat; N is the total number of species in the quadrat; N_i is the importance value of species i in the quadrat.

Results and analysis

Community species composition

The 12 shrub communities (Li et al., 2022) have different species compositions and different changing laws for plants in different families, which affects the shrub community structure, as shown in *Table 2*. The results showed that there are 20 species of plants in *Sabina pingii*, belonging to 15 families and 17 genera, and the proportion of plants in each family is evenly below 10%. There are 28 species of plants in Salix wangiana, belonging to 10 families, 23 genera, including 4 species of Rosaceae plants, accounting for 28.5%, 5 species of Compositae, accounting for 12.3%, 2 species of Cyperaceae, accounting for 10.7%, and all the other families account for less than 10%. There are 13 species of plants in *Potentilla fruticosa*, belonging to 6 families, 8 genera, including 3 species of Rosaceae plants, accounting for 33.3%, 2 species of Cyperaceae, accounting for 26.6%, and all the other families account for less than 10%. There are 16 species of plants in *Rhododendron mekongense* + *Rhododendron nivale*, belonging to 9 families, 10 genera, including 2 species of Cyperaceae, accounting for 19.3%, 2 species of Ericaceae, accounting for 16.1%, 1 species of Polygonaceae, accounting for 12.9%, and all the other families account for less than 10%. There are 17 species of plants in *Rhododendron nivale* + *Spiraea bella*, belonging to 12 families, 15 genera, including 4 species of Rosaceae, accounting for 20%, 3 species of Compositae, accounting for 15%, and all the other families account for less than 10%. There are 12 species of plants in

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Rhododendron nyingchiense + *Rhododendron nivale*, belonging to 9 families, 11 genera, including 3 species of Ericaceae, accounting for 22.9%, 2 species of Compositae, accounting for 15.3%, and all the other families account for less than 10%. There are 16 species of plants in *Cotoneaster buxifolius* + *Berberis parisepala*, belonging to 9 families, 16 genera, including 2 species of Rosaceae, accounting for 26.3%, 4 species of Compositae, accounting for 21%, 1 species of Leguminosae and Compositae, respectively, accounting for 21%, and all the other families account for less than 10%. There are 29 species of plants in *Rosa macrophylla* + *Berberis parisepala*, belonging to 20 families, 28 genera, and plants in each family account for less than 10%. There are 24 species of plants in *Caragana alpina* + *Berberis parisepala*, belonging to 18 families, 22 genera, including 3 species of Ranunculaceae, accounting for 12.1%, and all the other families account for less than 10%. There are 11 species of plants in *Artemisia gmelinii* + *Sophora moorcroftiana*, belonging to 9 families, 10 genera, including 2 species of Leguminosae, accounting for 22.5, 1 species of Labiatae, Compositae, and Gramineae, respectively, all accounting for 12.9, and all the other families account for less than 10%. There are 21 species of plants in *Sophora moorcroftiana* + *Leptodermis forrestii*, belonging to 13 families, 18 genera, including 6 species of Compositae, accounting for 34.8%, 2 species of Rosaceae, accounting for 13.9, and all the other families account for less than 10%. There are 25 species of plants in *Quercus aquifolioides*, belonging to 14 families, 18 genera, including 5 species of Rosaceae, accounting for 18.2%; all the other families account for less than 10%.

As a whole, the 12 typical shrub communities in southeastern Tibet are relatively rich in composition, with 230 species of plants belonging to 49 families and 107 genera. Where, Cyperaceae and Rosaceae appear in all the 12 communities. Rosaceae is relatively dominant in *Salix wangiana*, *Potentilla fruticosa*, *Rhododendron nivale* + *Spiraea bella*, *Cotoneaster buxifolius* + *Berberis parisepala* Formation, *Sophora moorcroftiana* + *Leptodermis forrestii*, *Quercus aquifolioides*, which is also one common dominant family in the other 6 communities. Compositae and Leguminosae have slightly lower proportion than Rosacea in the investigated communities, and Compositae and Leguminosae plants are also common in the 12 typical shrub communities.

Table 2. *Changes in plant composition of typical shrub communities in southeastern Tibet*

Formation type	Division (number of genera, % of total genera, number of species, % of total species)
Sabina pingii	Cupressaceae (1, 5.8, 1, 5), Primulaceae (1, 5.8, 1, 5), Dipsacaceae (1, 5.8, 1, 5), Euphorbiaceae (1, 5.8, 1, 5), Leguminosae (1, 5.8, 1, 5), Compositae (2, 11.7, 2, 10), Gentianaceae (1, 5.8, 1, 5), Rosaceae (1, 5.8, 1, 5), Thymelaeaceae (1, 5.8, 1, 5), Apiaceae (1, 5.8, 1, 5), Cyperaceae (2, 11.7, 2, 10.6), Caryophyllaceae (1, 5.8, 1, 5), Berberidaceae (1, 5.8, 1, 5), Scrophulariaceae (1, 5.8, 1, 5), Bignoniaceae (1, 5.8, 1, 5)
Salix wangiana	Primulaceae (2, 8.6, 2, 7.1), Dipsacaceae (1, 4.3, 1, 3.5), Euphorbiaceae (1, 4.3, 1, 3.5), Leguminosae (1, 4.3, 1, 3.5), Ericaceae (1, 4.3, 1, 7.1), Violaceae (1, 4.3, 1, 3.5), Compositae (5, 21.7, 5, 17.8), Polygonaceae (1, 4.3, 2, 7.1), Gentianaceae (1, 4.3, 1, 3.5), Geraniaceae (1, 4.3, 1, 3.5), Ranunculaceae (1, 4.3, 1, 3.5), Rosaceae (3, 13, 3, 10.7), Cyperaceae (1, 4.3, 2, 7.1), Scrophulariaceae (1, 4.3, 2, 7.1), Salicaceae (1, 4.3, 2, 7.1)
Potentilla fruticosa	Primulaceae (1, 12.5, 1, 7.6), Tamaricaceae (1, 12.5, 1, 7.6), Leguminosae (1, 12.5, 1, 7.6), Polygonaceae (2, 25, 2, 15.3), Rosaceae (2, 25, 2, 15.3), Cyperaceae (2, 25, 2, 15.3),
Rhododendron mekongense + R. nivale	Primulaceae (1, 10, 1, 6.25), Tamaricaceae (1, 10, 1, 6.25), Leguminosae (1, 10, 1, 6.25), Ericaceae (1, 10, 2, 12.5), Gramineae (1, 10, 1, 6.25), Polygonaceae (1, 10, 2, 12.5), Rosaceae (1, 10, 3, 18.7), Cyperaceae (2, 20, 2, 12.5), Salicaceae (1, 10, 1, 6.25)

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Rhododendron nivale + Spiraea bella	Liliaceae (1, 6.6, 1, 5.8), Primulaceae (1, 6.6, 1, 5.8), Juncaceae (1, 6.6, 1, 5.8), Ericaceae (1, 6.6, 2, 11.7), Violaceae (1, 6.6, 1, 5.8), Compositae (3, 20, 3, 16.3), Polygonaceae (1, 6.6, 1, 5.8), Gentiana (1, 6.6, 1, 5.8), Geraniaceae (1, 6.6, 1, 5.8), Rosaceae (3, 20, 4, 23.5), Scrophulariaceae (1, 6.6, 1, 5.8), Salicaceae (1, 6.6, 1, 5.8)
Rhododendron nyingchiense + Rhododendron nivale	Labiatae (1, 9.09, 1, 8.3), Ericaceae (2, 18.1, 3, 25), Violaceae (1, 9.09, 1, 8.3), Campanulaceae (1, 9.09, 1, 8.3), Compositae (2, 18.1, 2, 16.6), Polygonaceae (1, 9.09, 1, 8.3), Rosaceae (1, 9.09, 1, 8.3), Cyperaceae (1, 9.09, 1, 8.3), Salicaceae (1, 9.09, 1, 8.3)
Cotoneaster buxifolius + Berberisparisepala	Plantaginaceae (1, 6.25, 1, 6.25), Leguminosae (1, 6.25, 1, 6.25), Poaceae (2, 12.5, 2, 12.5), Compositae (1, 6.25, 1, 6.25), Gentianaceae (1, 6.25, 1, 6.25), Rosaceae (3, 18.7, 3, 18.7), Cyperaceae (1, 6.25, 1, 6.25), Berberidaceae (1, 6.25, 1, 6.25), Boraginaceae (1, 6.25, 1, 6.25)
Rosa macrophylla + Berberis parisepala	Liliaceae (2, 7.1, 2, 6.8), Primulaceae (1, 3.5, 1, 3.4), Dipsacaceae (1, 3.5, 1, 3.4), Labiatae (2, 7.1, 2, 6.8), Euphorbiaceae (1, 3.5, 1, 3.4), Leguminosae (1, 3.5, 1, 3.4), Poaceae (1, 3.5, 1, 3.4), Violaceae (1, 3.5, 1, 3.4), Crassulaceae (1, 3.5, 1, 3.4), Compositae (2, 7.1, 2, 6.8), Ranunculaceae (2, 7.1, 2, 6.8), Rosaceae (2, 7.1, 2, 6.8), Thymelaeaceae (1, 3.5, 1, 3.4), Apiaceae (2, 7.1, 2, 6.8), Cyperaceae (2, 7.1, 2, 6.8), Caryophyllaceae (2, 7.1, 2, 6.8), Adiantum (1, 3.5, 1, 3.4), Berberidaceae (1, 3.5, 1, 3.4), Iridaceae (1, 3.5, 2, 6.8), Boraginaceae (1, 3.5, 1, 3.4)
Caragana alpina + Berberis parisepala	Primulaceae (1, 4.5, 2, 8.3), Labiatae (1, 4.5, 2, 8.3), Leguminosae (2, 9.09, 2, 8.3), Solanaceae (1, 4.5, 1, 4.1), Compositae (1, 4.5, 1, 4.1), Chenopodiaceae (1, 4.5, 1, 4.1), Polygonaceae (1, 4.5, 1, 4.1), Onagraceae (1, 4.5, 1, 4.1), Ranunculaceae (3, 13.6, 3, 12.5), Rubiaceae (1, 4.5, 1, 4.1), Rosaceae (2, 9.09, 2, 8.3), Caprifoliaceae (1, 4.5, 1, 4.1), Brassicaceae (1, 4.5, 1, 4.1), Caryophyllaceae (1, 4.5, 1, 4.1), Berberidaceae (1, 4.5, 1, 4.1), Scrophulariaceae (1, 4.5, 1, 4.1), Salicaceae (1, 4.5, 1, 4.1)
Artemisia gmelinii + Sophora moorcroftiana	Primulaceae (1, 10, 1, 9.09), Labiatae (1, 10, 1, 9.09), Leguminosae (2, 20, 3, 27.2), Poaceae (1, 10, 1, 9.09), Compositae (1, 10, 1, 9.09), Gesneriaceae (1, 10, 1, 9.09), Chenopodiaceae (1, 10, 1, 9.09), Oleaceae (1, 10, 1, 9.09), Scrophulariaceae (1, 10, 1, 9.09),
Sophora moorcroftiana + Leptodermis forrestii	Cupressaceae (1, 5.2, 1, 4.7), Leguminosae (1, 5.2, 1, 4.7), Poaceae (1, 5.2, 1, 4.7), Compositae (5, 26.3, 6, 28.5), Pteridiaceae (1, 5.2, 1, 4.7), Plumbaginaceae (1, 5.2, 1, 4.7), Chenopodiaceae (1, 5.2, 1, 4.7), Oleaceae (1, 5.2, 1, 4.7), Rosaceae (3, 15.7, 3, 14.2), Apiece (1, 5.2, 1, 4.7), Brassicaceae (1, 5.2, 1, 4.7), Caryophyllaceae (1, 5.2, 1, 4.7), Boraginaceae (1, 5.2, 1, 4.7)
Quercus aquifolioides	Plantaginaceae (1, 5.5, 1, 4), Labiatae (3, 16.6, 3, 12), Leguminosae (1, 5.5, 1, 4), Ericaceae (1, 5.5, 1, 4), Compositae (1, 5.5, 1, 4), Fagaceae (1, 5.5, 1, 4), Polygonaceae (1, 5.5, 1, 4), Dryopteridaceae (1, 5.5, 1, 4), Onagraceae (1, 5.5, 1, 4), Rosaceae (4, 22.2, 4, 16), Caprifoliaceae (1, 5.5, 1, 4), Hyperspace (1, 5.5, 1, 4), Polypodiaceae (1, 5.5, 1, 4), Berberidaceae (1, 5.5, 1, 4)

Community species diversity

Table 3 reflects the species diversity of the 12 typical shrub communities. On the whole, the 12 typical shrub communities have simple structure and relatively low species diversity. The D diversity index is between 0.74~0.98; the H diversity index is between 1.85~2.96. Different shrub communities have different community environment, structure and stability, resulting in different community diversity. The evenness index (J) reflects the evenness in community distribution. *Rhododendron-nyingchiense* + *Rhododendron nivale* has the highest evenness index of 1.8, and the species is evenly distributed. *Sabina pingii* has a flaky distribution, with evenness index of only 0.60. The community dominance index (C) and the diversity index show opposite change patterns. *Rosa macrophylla* + *Berberis parisepala* with a low species diversity index has fewer species and higher dominance. Therefore, under normal circumstances, species diversity in ecosystems is not high due to limitation of certain environmental factors.

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Table 3. *Basic characteristics and species diversity of typical shrub communities*

Formation	The main companion species in the shrub layer	Main dominant species of herb layer	Average height (cm)	Coverage (%)	Importance value	*D*	*H*	J_{sw}	*C*
Sabina pingii	*Berberis kongboesis, Potentilla fruticosa*	*Kobresia pygmaea, Euphorbia stracheyi, Gentiana farreri, Aster tataricus*	27.7b	10a	0.69	0.86a	2.13a	0.60a	0.7a
Salix wangiana	*Rhododendron nivale, Potentilla fruticosa, Spiraea salicifolia*	*Carex arenaria, Potentilla chinensis, Aster tataricus, Primula atrodentata, Carex cardiolepis*	32.6a	14.7b	0.36	0.96a	2.01a	0.71a	0.45a
Potentilla fruticosa	*Myricaria rosea*	*Fragaria nubicola, Potentilla multifida, Carex cardiolepis, Polygonum macrophyllum, Astragalus bomiensis*	10.9a	13.4a	0.7	0.85a	1.87a	0.8a	0.62b
Rhododendron mekongense + Rhododendron nivale	*Myricaria rosea, Salix brachista*	*Carex cardiolepis, Astragalus bomiensis, Potentilla multifida, Polygonum macrophyllum, Kobresia myosuroides*	19.5b	16.4a	0.7	0.86a	1.9a	1.2c	0.72a
Rhododendron nivale + Spiraea bella	*Potentilla fruticosa, Rhododendron nying*	*Potentilla biflora, Juncus thomsonii, Aster tataricus, Polygonum viviparum, Anaphalis nepalensis*	21.1a	10.2a	0.8	0.98a	2.07a	1.2b	0.42b
Rhododendronnyingchiense + Rhododendron nivale	*Potentilla fruticosa, Salix brachista*	*Cassiope fastigiata, Polygonum viviparum, Carex cardiolepis, Ligularia hodgsonii, Leibnitzia nepalensis*	30a	15.8a	0.97	0.87a	1.99a	1.8c	0.53
Cotoneaster buxifolius + Berberis parisepala	*Rosa macrophylla*	*Plantago depressa, Oxytropis tracheyana, Poali twinowiana, Carex cardiolepis, Gentiana farreri*	88.9b	14.1a	0.81	0.87a	2.05a	1.2b	0.6b
Rosamacrophylla + Berberis parisepala	\	*Poali twinowiana, Kobresia pygmaea, Potentilla saundersiana*	44.1a	5.5a	0.56	0.91a	2.96a	1.0a	0.29a
Caragana alpina + Berberisparisepala	*Salix cupularis, Rosa sp., Lonicera japonica*	*Primula asarifolia, Salvia przewalskii, Anemone rivularis, Epelobium hirsutum, Anisodus tanguticus*	116.2a	14a	0.65	0.95a	1.95a	0.81b	0.5b
Artemisia gmelinii + Sophoramoorcroftiana	*Rabdosia amethystoide Syringa persica Linn*	*Poa litwinowiana, Androsace strigillosa, Corallodiscus lanuginosus, Phtheirospermumjaponicum, Astragalusmongholicus*	39.3a	12.3a	0.91	0.74b	1.98a	1.8a	0.74a
Sophora moorcroftiana + Leptodermis forrestii	*Artemisia gmelinii, Spiraea salicifolia, Plumba ginaceae*	*Artemisia scoparia, Artemisia sacrorum, Anaphalisxylorhiza Poalitwinowiana, Stellaria graminea, Trigonotispeduncularis*	66.8a	29.7a	0.75	0.85c	1.92a	0.91b	0.55a
Quercus aquifolioides	*Berberis parisepala, Cotoneaster buxifolius, Rosa macrophylla*	*Carex cardiolepis, Fragaria nubicola, Lepisorusthunbergianus, Potentillasaundersiana, Circaea alpina*	66.7a	31.1a	0.61	0.9a	1.85b	0.74a	0.38a

Different lowercase letters a, b in the same column indicate significant differences between different shrub communities ($P < 0.05$); D, H, Jsw, and C indicate Simpson diversity index, Shannon-Wiener diversity index, Pielou evenness index, and Simpson dominance index, respectively. The same below

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Interlayer distribution characteristics of community species diversity

The species diversity characteristics are different between the shrub layer and the herb layer of the 12 shrub communities, as shown in *Table 4*. Where, in the 8 communities of *Sabina pingii*, *Salix wangiana*, *Potentilla fruticosa*, *Rhododendron mekongense* + *Rhododendron nivale*, *Cotoneaster buxifolius* + *Berberis parisepala*, *Rosa macrophylla* + *Berberis parisepala*, *Caragana alpina* + *Berberis parisepala*, *Artemisia gmelinii* + *Sophora moorcroftiana*, the herb layer has higher species diversity index than the shrub layer, indicating that there are more herb species in the above shrub communities, and the herb layer has a relative advantage. In *Sophora moorcroftiana* + *Leptodermis forrestii* and *Quercus aquifolioides*, the shrub layer and herb layer have similar species diversity indexes, indicating that the shrub and herb layers in this community have relatively uniform species composition. The reason is that the vertical structure of plant communities is a result of combined action of hydrothermal conditions, microhabitats, population composition and developmental stages of the community [11]. There are different levels of D, H, Jsw, and C in the 12 typical shrub communities. For shrub layer, *Sabina pingii* has the highest D, *Rhododendron nivale* + *Spiraea bella* has the highest H, *Artemisia gmelinii* + *Sophora moorcroftiana* has the highest Jsw, C. For the herb layer, *Salix wangiana* has the highest D, *Rosa macrophylla* + *Berberis parisepala* have the highest H, C, and Sabina pingii has the highest Jsw. In general, for the 12 typical shrub communities, except for Sabina pingii, *Rhododendron nyingchiense* + *Rhododendron nivale*, *Sophora moorcroftiana* + *Leptodermis forrestii*, *Quercus aquifolioides*, the herb layer in the other shrub communities has greater species diversity than the shrub layer. This indicates that different habitats and different types of shrubs have different dominant growth types.

Table 4. *Diversity analysis of different growth types of shrub communities*

Community	Growth type	D	H	Jsw	C
Sabina pingii	Shrub	0.85	0.4	0.13	0.08
	Herb	0.78	0.73	0.31	0.28
Salix wangiana	Shrub	0.49	0.51	0.18	0.08
	Herb	0.93	0.49	0.23	0.02
Potentilla fruticosa	Shrub	0.36	0.29	0.12	0.05
	Herb	0.53	0.58	0.07	0.06
Rhododendron mekongense + Rhododendron nivale	Shrub	0.38	0.53	0.18	0.08
	Herb	0.47	0.34	0.04	0.03
Rhododendron nivale + Spiraea bella	Shrub	0.62	0.7	0.18	0.16
	Herb	0.74	0.73	0.05	0.03
Rhododendronnyingchiense + Rhododendron nivale	Shrub	0.34	0.65	0.16	0.13
	Herb	0.2	0.35	0.04	0.03
Cotoneaster buxifolius + Berberisparisepala	Shrub	0.34	0.6	0.2	0.12
	Herb	0.47	0.38	0.07	0.15
Rosamacrophylla + Berberis parisepala	Shrub	0.5	0.3	0.15	0.09
	Herb	0.74	0.77	0.03	0.59
Caragana alpina + Berberis parisepala	Shrub	0.24	0.5	0.1	0.25
	Herb	0.26	0.42	0.02	0.18
Artemisia gmelinii + Sophora moorcroftiana	Shrub	0.31	0.75	0.19	0.56
	Herb	0.34	0.2	0.03	0.04
Sophora moorcroftiana + Leptodermis forrestii	Shrub	0.38	0.65	0.13	0.43
	Herb	0.33	0.3	0.02	0.11
Quercus aquifolioides Formation	Shrub	0.3	0.54	0.11	0.29
	Herb	0.29	0.32	0.02	0.1

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Discussion

After research and investigation, it was found that the main typical shrub communities in southeastern Tibet mainly include Sabina pingii, *Salix wangiana*, *Potentilla fruticosa*, *Rhododendron mekongense* + *Rhododendron nivale*, *Rhododendron nivale* + *Spiraea bella*, *Rhododendron nyingchiense* + *Rhododendron nivale*, *Cotoneaster buxifolius* + *Berberis parisepala*, *Rosa macrophylla* + *Berberis parisepala*, *Caragana alpina* + *Berberis parisepala*, *Artemisia gmelinii* + *Sophora moorcroftiana*, *Sophora moorcroftiana* + *Leptodermis forrestii* and *Quercus aquifolioides*, a total of 12 typical communities. Due to different habitat conditions and community types, different shrub communities have significantly different species composition. Shrub communities in southeastern Tibet have diverse compositions, with 230 species of plants belonging to 49 families and 107 genera. This is related to the climate conditions in southeastern Tibet and habitat conditions of the shrub community. Rosaceae, Compositae and Leguminosae are the dominant varieties, which is consistent with the characteristics of Rosaceae, Compositae and Leguminosae in arid areas (Ma et al., 1995). Different environmental resources and their heterogeneity are one primary reason for the different community structure characteristics and plant community diversity distribution patterns (Dang et al., 2002). In the study area, the average altitude is 3100 m, and the herb species are abundant, possibly due to the superior hydrothermal conditions in the area, which is suitable for the growth of herb species (Su et al., 2019; Qu et al., 2019). Hence, the herb species have greater diversity than other species. *Sabina pingii* Formation, *Rhododendron nyingchiense* + *Rhodode-ndron nivale* are distributed in areas higher than 3,200 m above sea level. The climate is cold with great evaporation, and the low temperature inhibits the growth of understory plants. At the same time, *Sophora moorcroftiana* + *Leptodermis forrestii* community, *Quercus aquifolioides* have high shrub coverage, as shown in *Table 3,* so the lower herb plants cannot receive sufficient sunshine, leading to low species diversity. This study also showed that the maximum D and H of the shrub community in southeastern Tibet was 0.96, 2.96, respectively. According to species diversity study of shrub communities in other regions, the diversity index H of the shrub communities on the Qilian Mountain Plateau is 1.12~2.26 (Wang et al., 2007), the diversity index H of shrub communities in Urumqi is 0.95~3.06 (Zhang et al., 2016), the diversity index of shrub communities in desertification grassland of the Ordos Plateau is 1.86~3.41 (Li et al., 1999). This shows that shrub community in southeastern Tibet has low species diversity index, single dominant species have high community dominance, a phenomenon related to the ecosystem of southeastern Tibet. However, a low diversity index does not mean poor system stability. Some communities have simple structure, mainly single dominant populations with high stability (Li X R, et al., 2008). For a fragile ecosystem, if the dominant species in the community disappears without replacement by similar species with similar ecological functions, then it will cause great damage to the ecosystem (Ding et al., 2014). As a result, we need strengthen protection of shrub community. Plant diversity distribution is subject to the influence of its own biological characteristics and natural environment, as well as external interferences. Different types and intensities of interferences may lead to community structure changes. Studies have shown that interference will lead to reduced species diversity (Feng et al., 2006), and different life-form plants in the same community have significantly different response to external interference (Hao et al., 2016). The investigation found that the shrubs in southeastern Tibet are less interfered by the outside world. Grazing

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interference is the biggest interference to the shrub community, but it is only a slight one. Therefore, the evolution and replacement of the shrub community basically proceeds in a natural state. In the high-altitude ecological environment, the slow growth and renewal of shrubs limits the ecological niche of shrub species to a certain extent. Plus the rapid renewal of herb plants (Qu et al., 2019), the combined effect of multiple factors results in higher species diversity of herb plants.

Conclusion

The 12 typical shrub communities in southeastern Tibet have relatively diverse composition. 230 species of plants belonging to 49 families and 107 genera were found in the 29 sample plots surveyed, but mainly dominant species of Rosaceae, Gramineae, Compositae and Leguminosae in arid areas. H diversity index varies between 1.85~2.96, and D diversity index varies between 0.74~0.96. The species diversity index is low, and herb layer has great dominance in species diversity. However, low species diversity does not mean poor system stability. For the ecosystem of southeastern Tibet, disappearance of the dominant species in the community will cause extremely serious damage to the entire ecosystem function, so we must strengthen key protection of shrub communities.

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