# Analysis of Plant Diversity Characteristics in Jiangxia Wetland

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**Abstract** [**Objectives**] This study was conducted to explore the characteristics of plant diversity of Jiangxia Wetland in Lhasa River basin. [**Methods**] Based on the survey data of 37 plant community in three types of sample plots of Jiangxia Wetland in the Lhasa River basin, this study analyzed the diversity of plant community in different habitats of Jiangxia Wetland from Pielou evenness, Margalef richness, Simpson and Shannon Wiener diversity indexes of different types and levels. [**Results**] The Pielou index, Shannon – Wiener index and Simpson diversity index of dry land was higher than those of other plots, while the Margalef species richness index of the ecotone of seasonally flooded and dry land was higher than that of other plots. The Pielou index, Shannon – Wiener index, Simpson diversity index and Margalef species richness index of composite plants were higher than those of other herbaceous plants. The Shannon – Wiener index, Simpson diversity index and Margalef species richness index of hygrophytes were higher than those of other plants, while the Pielou index evenness index of aquatic plants was higher than that of other plants. Annual or perennial herbaceous plants occupied the primary position in the study area, and shrub plants occupied a secondary position, and floating plants took the lowest position. [**Conclusions**] The results of this study can provide theoretical support or reference basis for the scientific management of comprehensive wetland systems such as wetland ecosystem restoration and plant diversity protection in Jiangxia Wetland.

**Key words** Diversity index; Aquatic plant; Hygrophyte; Drought-tolerant plant

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In recent years, due to the rapid development of urbanization, the appearance of extreme climate and the intensification of human disturbance activities, various plants in wetlands have been destroyed to varying degrees, and the structure, quantity and species of plant populations have changed significantly[1–3]. Therefore, it is particularly necessary to strengthen the study of various plant populations in wetlands, in order to identify the degradation mechanism of plants more accurately and actively and reasonably explore the best way to repair river damage by various vegetation in wetlands simultaneously[4–5]. In this study, the diversity of vegetation populations in Jiangxia Wetland Nature Reserve was analyzed from two aspects, including the characteristics of flora in the study area and various diversity indexes of plant populations and their correlation analysis. Strengthening the study of wetland plant communities in Tibet, gaining a deeper understanding of the evolution mechanisms of wetland vegetation, and exploring the restoration and utilization of wetland vegetation have significant value and importance. Therefore, the analysis on plant community diversity in Jiangxia Wetland provides reference for vegetation protection and restoration of Jiangxia Wetland[6].

## Materials and Methods

### General situation of study area

The Qinghai – Tibet Plateau is rich in ecosystem types. According to statistics, the total area of wetland ecosystem is over 6 million $hm^2$, ranking first in China[7]. Jiangxia Wetland is a seasonal herbaceous swamp wetland, with an area of about 670 000 $hm^2$[6]. The geographical location near the center of the wetland is 91°20′36.41″ E, 29°51′55.10″ N, with an altitude of 3 746 m. The climate type belongs to the temperate plateau monsoon climate zone, with a mild climate, which has an average annual temperature of 5.8 ℃ and abundant water, and the rainy season is from June to September every year. During the flood season of Lhasa River, the groundwater level in the wetland is rising continuously, and the surface is too wet or water accumulates to form a shallow swamp wetland. Winter and spring are the dry season of Lhasa River or the level of groundwater decreases, which makes most wetlands in a state of water loss, which further causes the formation of grassland[8]. The wetland vegetation mainly consists of Kobresia pygmaea, Carex moorcroftii, Kobresia robusta, Argentina anserina, Eleocharis valleculosa and Primula tibetica.

### Investigation methods

The setting of sample plots for vegetation surveys in wetland ecosystem mainly follows different elevations relative to the water surface, and the survey was conducted by combining the belt transect methods and sample plots, specifically 0.5 m × 0.5 m grassland plots and 5 m × 5 m shrub plots. The main indicators surveyed include the number of species (recording species names), individual counts, plot numbers, heights, coverage, altitude, and geographic coordinates. The species of each plant in the quadrats was identified on the spot. The species that could not be identified on the spot were collected, and the samples were sealed and brought back to the laboratory for identification. The importance value of species was calculated according to following equation:

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Importance value of species = (Relative coverage + Relative abundance + Frequency)/3.

## Data processing and analysis

The recorded and collected species were classified, and the plant species in the wetland were identified according to *Flora of China*, *Wetland Plants* and other related works or documents[9-14]. On this basis, the plant species, genera and families were counted and the ecological types of plants were clarified, and the characteristics of plant diversity in Jiangxia Wetland were put forward[14].

Shannon - Wiener Diversity Index ($H'$) refers to the probability of individuals appearing in an infinite community, assuming that the individuals are randomly sampled in the infinite community and the samples contain all species in the community. The calculation formula[15-17] is as follows:

$$H' = -\sum_{i=1}^{S} P_i \ln P_i$$

Margalef richness index ($D_m$) refers to the number of species in a sample of a certain size when only considering the number of species and total individuals in the community. The calculation formula[15-17] is as follows:

$$D_m = (S-1)/\ln N$$

Pielou evenness index ($J_s$) refers to the probability that individuals of two different species in a sample meet, assuming that randomly sampling is performed in an infinite community. Pielou evenness index reflects the evenness of biological composition. The calculation formula[15-17] is as follows:

$$J_s = H'/\ln S$$

Simpson index ($D$) refers to the probability that two different species in a sample meet, assuming that randomly sampling is performed in an infinite community. Simpson index provides a quantitative index for measuring the evenness of species distribution in a community. The calculation formula[15-17] is as follows:

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

In the formulas, $P_i$ is the relative importance value of species $i$; $S$ is the number of all species in quadrats; and $N$ is the sum of the importance values of species in all quadrats. The Kruskal - Wallis H method in nonparametric test of SPSS 18.0 was adopted to test the significance of differences in plant fresh weight, height, coverage and diversity index between elevations and slope grades. In the case of a significant difference at the significant level of 0.05, Dunnet's method was selected for multiple comparisons. Origin 2019 software was selected for drawing.

# Results and Analysis

## Characteristics of flora in the study area

The plants in Jiangxia Wetland showed rich diversity, with a total of 41 species belonging to 33 genera of 16 families (Table 1). Cyperaceae and Compositae were widely distributed wetland plants, including 16 species belonging to 10 genera, and the numbers of families, genera and species accounted for 12.5%, 30.0% and 39% of the total families, genera and species, respectively. Gramineae, Leguminosae, Rosaceae, Plantaginaceae and Primulaceae took the second place, with 16 species belonging to 16 genera, and the numbers of families, genera and species accounted for 31.3%, 48.5% and 39%, respectively. Above species were the constructive species and dominant species of Jiangxia Wetland. There were 32 species in Jiangxia Wetland, including Gramineae, Leguminosae, Rosaceae, Cyperaceae, Plantaginaceae, Compositae and Primulaceae. Among all the plants, 1 species of 1 genus of 1 family belonged to monocotyledonous plant, and all other plants were angiosperms, including 40 species in 32 genera of 15 families. Plants in the study area were mainly herbaceous, involving 39 species, such as *Kobresia pygmaea*, *Carex moorcroftii*, *Kobresia robusta* and *Argentina anserine*, accounting for a total of 61.48% of the life forms in the study area. There were three species of shrubs, namely *Caragana pygmaea*, *Artemisia moorcroftiana* and *Sibbaldianthe bifurca*, accounting for 1.67% of the life forms in the study area.

## Species importance analysis

The vegetation in the study area was dominated by herbs. According to the results of field investigation and the display of plant importance values (Table 1), there were two species in the study area with importance values greater than 10, and *K. pygmaea* and *Carex moorcroftii* showed the highest index values, at 26.72 and 11.90, respectively, accounting for a total 38.62% of the total importance values. It could be seen that *K. pygmaea* and *C. moorcroftii* were the absolute dominant species and constructive species for Jiangxia Wetland. There were 17 species with importance values greater than 1, accounting for a total of 52.01% of the total importance value, and they were sub-dominant species or pioneer species of the wetland. There were 22 species with importance values less than 1, accounting for a total of 9.37% of the total importance value, and they were companion species of the wetland.

## Analysis of plant community diversity in different types of sample plots

The sample plots for collection in the study area included dry land, seasonally flooded land, and the ecotone of seasonally flooded land and dry land, involving a total of 41 plant species (Table 1) in 37 small quadrat (0.5 m × 0.5 m). The coverage of plant community in the sample plots ranged from 14.68% to 39.21%, with the highest value in the ecotone of seasonally flooded land and dry land and the lowest value in dry land. Plant species ranged from 20 to 27, with the highest value observed in dry land and the lowest value in the ecotone of seasonally flooded land and dry land. Pielou index, Shannon - Wiener index and Simpson index in dry land were higher than other plots in the study area, while Margalef species richness index in the ecotone of seasonally flooded land and dry land was higher than other plots.

**Table 1 Plant species and importance values**

| No. | Species | Family | Genus | Habitat | Importance value |
|---|---|---|---|---|---|
| 1 | *Potamogeton natans* | Potamogetonaceae | *Potamogeton* | Aquatic | 1.33 |
| 2 | *Hippuris vulgaris* | Plantaginaceae | *Hippuris* | Aquatic | 0.72 |
| 3 | *Eleocharis valleculosa* | Cyperaceae | *Eleocharis* | Hygrophyte | 4.84 |
| 4 | *Myriophyllum verticillatum* | Halorrhagidaceae | *Myriophyllum* | Aquatic | 3.55 |
| 5 | *Schoenoplectus tabernaemontani* | Cyperaceae | *Schoenoplectus* | Aquatic | 0.27 |
| 6 | *Carex moorcroftii* | Cyperaceae | *Carex* | Hygrophyte | 11.90 |
| 7 | *Pedicularis longiflora* Rudolph | Orobanchaceae | *Pedicularis* | Hygrophyte | 2.54 |
| 8 | *Primula tibetica Watt* | Primulaceae | *Primula* | Hygrophyte | 5.34 |
| 9 | *Kobresia littledalei* | Cyperaceae | *Kobresia* | Hygrophyte | 2.98 |
| 10 | *Plantago depressa* | Plantaginaceae | *Plantago* | Hygrophyte | 2.14 |
| 11 | *Triglochin maritimum* | Juncaginaceae | *Triglochin* | Hygrophyte | 4.05 |
| 12 | *Kobresia pygmaea* | Cyperaceae | *Kobresia* | Hygrophyte | 26.72 |
| 13 | *Kobresia robusta* Maximowicz | Cyperaceae | *Kobresia* | Drought-tolerant | 6.69 |
| 14 | *Argentina anserina* | Rosaceae | *Argentina* | Hygrophyte | 7.06 |
| 15 | *Aster souliei Franch* | Compositae | *Aster* | Drought-tolerant | 0.87 |
| 16 | *Leontopodium pusillum* | Compositae | *Leontopodium* | Drought-tolerant | 1.80 |
| 17 | *Halerpestes tricuspis* | Ranunculaceae | *Halerpestes* | Hygrophyte | 2.67 |
| 18 | *Festuca rubra* | Gramineae | *Festuca* | Hygrophyte | 0.65 |
| 19 | *Pedicularis resupinata* | Orobanchaceae | *Pedicularis* | Drought-tolerant | 0.20 |
| 20 | *Elymus tangutorum* | Gramineae | *Elymus* | Hygrophyte | 0.34 |
| 21 | *Caragana pygmaea* | Leguminosae | *Caragana* | Drought-tolerant | 1.26 |
| 22 | *Taraxacum mongolicum* | Compositae | *Taraxacum* | Hygrophyte | 1.06 |
| 23 | *Piptatherum munroi* | Gramineae | *Piptatherum* | Hygrophyte | 0.27 |
| 24 | *Astragalus strictus* | Leguminosae | *Astragalus* | Hygrophyte | 1.54 |
| 25 | *Artemisia moorcroftiana* | Compositae | *Artemisia* | Drought-tolerant | 0.47 |
| 26 | *Artemisia demissa* | Compositae | *Artemisia* | Drought-tolerant | 0.59 |
| 27 | *Cynoglossum amabile* Stapf | Boraginaceae | *Cynoglossum* | Drought-tolerant | 0.63 |
| 28 | *Digitaria sanguinalis* | Gramineae | *Digitaria* | Hygrophyte | 1.23 |
| 29 | *Heteropappus semiprostratus* Griers | Compositae | *Heteropappus* | Drought-tolerant | 0.14 |
| 30 | *Poa annua* | Gramineae | *Poa* | Drought-tolerant | 0.13 |
| 31 | *Carex doniana* Spreng | Cyperaceae | *Carex* | Hygrophyte | 0.64 |
| 32 | *Medicago lupulina* | Leguminosae | *Medicago* | Hygrophyte | 0.49 |
| 33 | *Eragrostis pilosa* | Gramineae | *Eragrostis* | Hygrophyte | 0.90 |
| 34 | *Potentilla bifurca* Linn | Rosaceae | *Potentilla* | Drought-tolerant | 0.20 |
| 35 | *Lancea tibetica* | Mazaceae | *Lancea* | Hygrophyte | 0.74 |
| 36 | *Carex atrata* | Cyperaceae | *Carex* | Hygrophyte | 0.12 |
| 37 | *Pennisetum flaccidum* Griseb | Gramineae | *Pennisetum* | Drought-tolerant | 0.24 |
| 38 | *Glaux maritima* | Primulaceae | *Glaux* | Hygrophyte | 1.92 |
| 39 | *Leontopodium leontopodioides* | Compositae | *Leontopodium* | Drought-tolerant | 0.18 |
| 40 | *Luzula campestris* | Juncaceae | *Luzula* | Hygrophyte | 0.26 |
| 41 | *Cirsium argyracanthum* | Compositae | *Cirsium* | Hygrophyte | 0.34 |

**Analysis of plant community diversity in various families**

There were 39 species of herbaceous plants and 2 species of shrub plants. Cyperaceae, Rosaceae and Primulaceae accounted for 54.14%, 7.26% and 7.27% of the importance value, respectively, and the plants of other families accounted for less than 5.0%. The plant species of various families ranged from 2 to 8, with the highest values observed in Compositae and Cyperaceae and the lowest values in Orobanchaceae and Rosaceae. The results of plant community diversity indexes of various families showed (Fig. 2) that the Pielou index, Shannon–Wiener index, Simpson index and Margalef species richness index of Compositae were higher than those of other families, while the Pielou index, Shannon – Wiener index, Simpson index and Margalef species richness index of Rosaceae were lower than those of other families. The diversity of Juncaceae, Juncaginaceae, Mazaceae, Halorrhagidaceae, Potamogetonaceae, Ranunculaceae and Borraginaceae in the study area was poor overall, and the index was 0, while the plants of Cyperaceae, Rosaceae and Primulaceae were more stable and accounted for the largest proportion in all families.

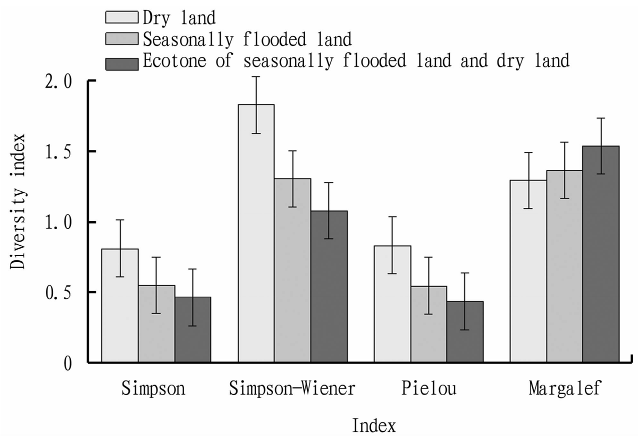


**Fig. 1 Plants diversity indexes of different types of sample plots**

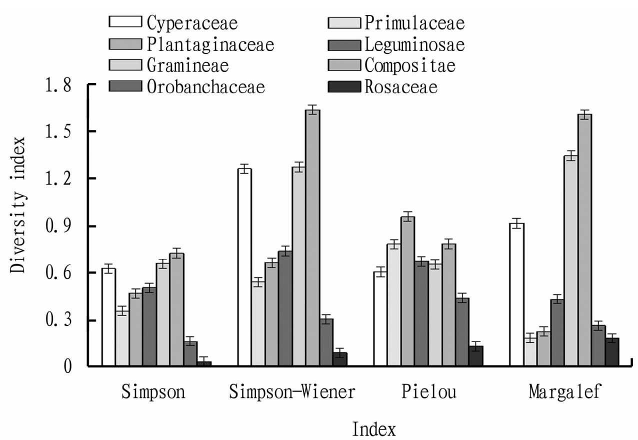


**Fig. 2 Diversity index of plant community of each family**

## Plant diversity analysis of different habitats

The plants collected in the study area can be divided into three types: aquatic, hygrophytic and drought-tolerant (Table 2). The results showed that the coverage of aquatic, hygrophytic and drought-tolerant plant communities accounted for 7.42%, 81.92% and 10.66% of the total coverage respectively, involving 41 plan species. There were 24 species of hygrophytes, being the most. The lowest value was 4, which was observed in aquatic plants, and there were 13 drought-tolerant plants. The highest $D$ value was obtained in hygrophytes, and aquatic plants showed the lowest value. The $H'$ value was highest in hygrophytes, and lowest in aquatic plants. The $J_s$ value was highest in aquatic plants, and lowest in drought-tolerant plants. The highest $D_m$ was in hygrophytes, and lowest in aquatic plants. The Shannon – Wiener index, Simpson index and Margalef species richness index of hygrophytes in the study area were higher than other plants, while Pielou index of aquatic plants was higher than other plants (Fig. 3).

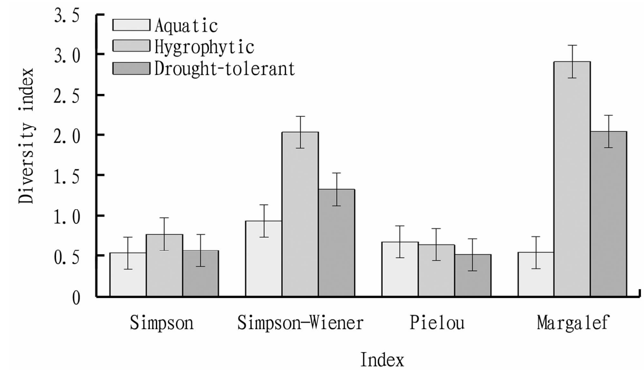


**Fig. 3 Diversity index of plant community in different habitats**

## Correlation analysis of plant diversity characteristics in the study area

**Correlation analysis of plant diversity indexes in various sample plots** The correlation analysis in different types of plots is shown in Table 2. Pielou evenness index ($J_s$) and Shannon – Wiener species diversity index ($H'$) of plant community showed the highest correlation coefficient. Simpson ecological dominance index ($D$) and Pielou evenness index ($J_s$), as well as Shannon – Wiener species diversity index ($H'$) and Simpson ecological dominance index ($D$), were in a positive correlation, with indexes of 0.999 and 0.998, respectively, while other indexes were negatively correlated. The highest correlation coefficient between Pielou evenness index (Js) and Shannon – Wiener species diversity index ($H'$) of plant community indicated that the diversity of plant community in different plots was mainly affected by Pielou evenness, which was an important factor affecting the plant community diversity index[14].

**Table 2 Correlation of plant diversity indexes in various sample plots**

| | $D$ | $H'$ | $J_s$ | $D_m$ |
|---|---|---|---|---|
| $D$ | 1 | | | |
| $H'$ | 0.998* | 1 | | |
| $J_s$ | 0.999* | 1.000* | 1 | |
| $D_m$ | −0.866 | −0.896 | −0.883 | 1 |

$D_m$: Margalef richness index; $D$: Simpson index; $J_s$: Pielou index; $H'$: Shannon – wiener diversity index.

**Correlation analysis of plant diversity indexes in various families**

The correlation analysis of plant diversity indexes among various families is shown in Table 3. Simpson ecological dominance index ($D$) and Shannon – wiener's species diversity index ($H'$) showed the highest correlation coefficient, reaching 0.955. There was a positive correlation between Shannon – wiener species diversity index ($H'$) and Margalef richness index ($D_m$), and also between Simpson ecological dominance index ($D$) and Margalef richness index ($D_m$), with indexes of 0.927 and 0.803, respectively, while other indexes were negatively correlated. The highest correlation coefficient between Simpson ecological dominance index ($D$) and Shannon – wiener's species diversity index ($H'$) of plant community indicated that the diversity of plant community in various families was mainly influenced by Simpson ecological dominance index ($D$), which was an important factor affecting the diversity index of plant community in various families.

**Table 3 Correlation of plant diversity indexes in different families of plants**

| | $D$ | $H'$ | $J_s$ | $D_m$ |
|---|---|---|---|---|
| $D$ | 1 | | | |
| $H'$ | 0.955** | 1 | | |
| $J_s$ | 0.696 | 0.525 | 1 | |
| $D_m$ | 0.803* | 0.927** | 0.243 | 1 |

$D_m$: Margalef richness index; $D$: Simpson index; $J_s$: Pielou index; $H'$: Shannon – wiener diversity index.

### Correlation of plant community diversity indexes in different habitats

The correlation analysis of plant diversity indexes among different habitats is shown in Table 3. Simpson ecological dominance index ($D$), Shannon – wiener species diversity index ($H'$), Margalef richness index ($D_m$) and Simpson ecological dominance index ($D$) of plant community were all negatively correlated, indicating that plant community diversity in different habitats was not affected by each other, and hence, there was no significant correlation.

**Table 4 Correlation of plant community diversity indexes among different habitats**

| | $D$ | $H'$ | $J_s$ | $D_m$ |
|---|---|---|---|---|
| $D$ | 1 | | | |
| $H'$ | 0.977 | 1 | | |
| $J_s$ | 0.175 | -0.041 | 1 | |
| $D_m$ | 0.858 | 0.949 | -0.355 | 1 |

$D_m$: Margalef richness index; $D$: Simpson index; $J_s$: Pielou index; $H'$: Shannon – wiener diversity index.

## Conclusions

Among the three kinds of plots set up in the study area, Pielou index, Shannon – Wiener index and Simpson index of dry land were higher than other plots, while Margalef species richness index in the ecotone of seasonally flooded land and dry land was higher than other plots. It shows that species diversity refers to the evenness and richness of species distribution, which cannot be fed back by a single species or individual. Therefore, the large number of individuals or species alone does not mean that the diversity is high[18–19].

Among the 41 plants, Shannon – Wiener index, Simpson index and Margalef species richness index of hygrophytes were higher than other plants, while Pielou evenness index of aquatic plants was higher than other plants. It did not mean that hygrophytes or aquatic plants had strong adaptability to the environment. On the contrary, drought-tolerant plants such as *K. crassa*, *C. humilis* and *Leontopodium tenuifolium* had strong adaptability to the environment and played a key role in wetland vegetation and ecological environment restoration.

According to the correlation coefficient of plant diversity in different sample plots, families and habitats, Pielou evenness was an important factor affecting plant community diversity index in different sample plots, while plant community diversity in different families was mainly affected by Simpson ecological dominance index (D), and plant diversity in different habitats had no correlation, indicating that the growth of plants in different habitats was not affected by each other, so there was no significant correlation.

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was difficult for the roots to absorb Hg, while the ability of the roots to absorb other elements was relatively average. The migration factor results indicated that there were significant differences in the migration factors of different heavy metal elements in the same tissue, and there were also significant differences in the migration factors of the same heavy metal in different tissues. Overall, the migration factors of heavy metals in rice plant stems and leaves were significantly higher than those in rice husks and brown rice.

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