

Flora of Offshore Islands in Shandong Province, China[†]

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ABSTRACT : There are 474 species of native vascular plant distributed in offshore islands in Shandong Province, which belong to 262 genera and 82 families. The distribution types of genera of seed plant were classified into 15 types. Temperate characteristic is dominant in the flora of offshore islands and tropical characteristic ranks secondary. Therefore, some islands play the role of stepping islands. Furthermore, 98.85% of the total genera are monotypic or bitypic which shows the offshore habitat heterogeneity in Shandong Province.

Key words : Flora, Habitat heterogeneity, Offshore islands, Stepping island

INTRODUCTION

In this study, we analyzed the offshore island flora of Shandong Province on the base of a great deal of field work and put forward some concrete materials and related suggestion in order to protect the plant resources in these islands. Shandong Province is a coastal province in East China. Situated in the lower reaches of the Yellow River, it borders on the Bohai Sea and the Yellow Sea. Shandong faces Japan and the Korean Peninsula to the east. Shandong Province is located between 38° 32' 24" and 36° 32' 21" north latitude, 117° 51' 40" and 121° 39' 07" east longitude. It is 700 km wide from east to west and 420 km long from north to south. With a total land area of 156,700 km², it makes up 1.6% of the territory of China. More than 300 offshore islands distribute along the 3,121 km coastal line. The complex geographic characteristics bring the diversity of flora, especially in offshore islands.

MATERIALS AND METHODS

Climate

Shandong belongs to the warm temperate zone with semi-tropical monsoon climate in some parts. The annual average temperature is between 11°C and 14°C and annual average precipitation is 550~950 mm. The frost-free period in the coastal area lasts more than 180 days while in the inland areas it is more than 220 days. The offshore islands, north of Shandong peninsula are in the warm temperate Eastern-Asia monsoon climate zone. However, the southern islands belong to the oceanic climate zone with the attribute of oceanic climate in summer and continental climate in winter. The solar resource is one of the most important factors which influence the development and distribution of plants directly. According to the

statistics of meteorological materials, the annual sunlight of offshore islands averages to 2,742 hours, which is higher than that of the whole province. The statistics indicates that the sunlight resource here is very abundant which benefits a lot to the development of the plants. Another important factor that influences plants distribution is caloric condition. However, the annual temperature changes little in different offshore islands. The highest temperature appears in July and the lowest in January. Furthermore, precipitation also influences the plants distribution. The mean precipitation in offshore islands in Shandong Province is 638.8 mm. In fact, the precipitation distribution is not balanced in different seasons. The largest precipitation appears in summer and the smallest in winter and spring.

Soil

Soil plays a role of substrate for plant development and exchanging of material and energy. Therefore it influences plants distribution to some extent. The soil in offshore islands could be divided into the following five types: brown soil, cinnamon soil, damp soil, sea shore and shell sand. The shell sand only exists near Binzhou city, where it forms the distinguished shell-sand islands.

Human disturbance

Although climate and soil determine the plants distribution to a great extent, the human disturbance could not be ignored. Sometimes human activity can influence the plants distribution in a dominant way. Only a few islands are residential islands. Human disturbances mainly include piscatorial production, architectural industry and farming.

RESULTS

The flora analysis of Shandong offshore islands

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First, we analyzed the composition of families and genera and dominant species based on related materials (Wu 1991, Wang 1994, Wang and Zhou 2000). Second, we primarily listed the species of offshore islands according to the record of vegetation and the collected samples in offshore islands. Third, we summed up the attributes of flora distribution in offshore islands. There are 658 vascular plants in offshore islands, which belong to 88 families and 310 genera. Among 658 species, 474 vascular species and variations are wild which belong to 82 families and 262 genera. Angiosperm accounts for 95.78% of total offshore island species while pteridophyte and gymnosperm make up 4.22%. The data indicates that angiosperm makes the leading effects on the offshore island flora. The proportion of genus to family and species to genus were very small, which shows 2.96:1 and 1.67:1 respectively. The plants with the attribute of only one genus in a family and one species in a genus were in the majority of the flora on offshore islands.

There are 4 larger families in offshore islands flora which include 47 species of Compositae, 35 species of Gramineae, 35 species of Leguminosae and 20 species of Cyperaceae. These 4 families are the most dominant in Shandong offshore island flora. The larger families in flora of Shandong Province are Gramineae (155), Compositae (102), Cyperaceae (20) and Leguminosae (78), which are very similar to the offshore-island flora. The total species of offshore island account up to 25~50% in total in Shandong Province. However, we have to point out that there are 6 genera and 17 species in Chenopodiaceae. Although the species are less than that of the above-mentioned 4 families, many of them are salt-resistant species and sometimes are constructive species which play an important role in the flora of Binzhou area.

Life-form analyses

In the flora of Shandong offshore islands, there are 383 herbage species, 15 liana species and 56 woody plants, accounting for 84.36%, 3.30% and 12.33% respectively. We may find that herbage takes the dominance, which is accordant with the dominant vegetating in Shandong offshore islands.

Life form is a kind of fitfulness to composite environment, which is often expressed in appearance. Therefore, the analysis on the composition of life form could help us to know the appearance and structure of community and directly indicate the environmental conditions. Based on the statistics of the life form of 474 species, we could find that hemicryptophyte, geophyte and therophyte took the dominance, accounting for 28.9%, 34.6% and 28.0% respectively. The composition of life form showed that the vegetation had the attribute of temperate herbage.

Analyses on distribution types of genus

According to the distribution types classification of genus of seed plants in China (Wu 1991), 15 distribution types of genus in offshore islands were listed as following:

Cosmopolitan distribution: includes 51 genera and 133 species. *Chenopodium*, *Polygonum*, *Plantago*, *Carex*, *Limonium*, *Astragalus*, *Atriplex*, *Galium* and *Digitaria* are the dominant compositions of aquatic and marsh vegetation in Changshan Island. *Potamogeton*, *Typha*, *Phragmites*, *Cyperus*, *Lemna*, *Ceratophyllum* and *Juncus* distribute in other islands of Binzhou area. We may omit cosmopolitan type during statistics because it can hardly determine the relationship of flora and the trait of geographical distribution.

Pantropical distribution: includes 42 genera and 72 species, which account for 21.99% and 16.02% respectively. The common species are *Ziziphus*, *Vitex*, *Potulaca*, *Tribulus*, *Euphorbia*, *Setaria*, *Commelina*, *Aristolochia*, *Calystegia*, *Cynanchum*, *Euonymus* in which *Ziziphus* and *Vitex* are distributed in almost all the islands while *Euonymus* could only be found in Peninsula area.

Tropical Asia & Tropical American disjuncted: only 3 genera and 3 species in this type are found in Shandong offshore islands which include *Quamoclit*, *Picrasma* and *Messerschmidia*. *Picrasma* appears in Chang Island and *Messerschmidia* is often found in shell-sand islands.

Old World Tropics: includes 6 genera and 7 species. There is little distribution of this type.

Tropical Asia & Tropical Australia: includes 4 genera and 4 species. *Cuclrania* is distributed in large area in Lingshan island. *Evodia* is scattered only in Changshan island.

Tropical Asia to Tropical Africa: includes 2 genera and 2 species namely *Glycine* and *Periploca*. *Glycine* is widely distributed in islands near Binzhou area.

Tropic Africa: includes 8 genera and 12 species. *Camellia* and *Machims* are only distributed in Changmenyan island. *Broussonetia* is distributed on shell sand.

North Temperate: includes 64 genera and 107 species which account for overwhelming majority with 18% and 48% respectively. There are 9 species in *Artemisia*, 4 species in *Potentilla* and *Prunus*, 3 species in *Quercus* and *Sedum* respectively. Among other 51 genera, there are 45 monotypic genera and 6 bitypic genera. The common species are as following: *Humulus*, *Leymus*, *Kochia*, *Ulmus*, *Salicornia*, *Puccinellia*, *Calamagrostis*, *Echinochloa*, *Onchus*, *Tripolium*, *Sanguisorba*, *Crisium*, *Descurainia*, *Rubia*, *Orobanche*, *Lycium*, *Prunella*, *Mentha*, *Glechoma*, *Daucus*, *Agrimonia*, *Silene*.

East Asia-North America disjuncted: includes 13 genera and 18 species. Three species belong to liana, namely *Ampelopsis*, *Trachelospermum* and *Menispermum*. The others are herbage which consists of *Apocyum*, *Lespedeza*, *Glehnia*, *Nelumbo*, *Acorus*, *Mosla*, *Zizania*.

Old World Temperate: includes 33 genera and 50 species. Most of them are monotypic and bitypic genera which consist of *Dianthus*, *Melilotus*, *Dendranthema*, *Tamarix*, *Roegneria*, *Scorzonera*, *Imula*, *Nepeta*, *Leonurus*, *Thymus*, *Lagopsis*, *Oenanthe* and *Malachium*.

Temperate Asia: includes 4 genera and 9 species. One genus and 3 species of them are shrub, namely *Caragana*. The others are herbage which consists of *Orostachys*, *Gueldenstaedtia* and *Trigonotis*.

Mediterranean, West Asia to Middle Asia: includes 11 genera and 12 species. *Nitraria* and *Pistacia* are woody plants. The others are herbage which consists of *Aeluropus*, *Glycyrrhiza*, *Erysimum* and *Malcolmia*. Furthermore, *Aeluropus* is one of the constructive species in islands near Binzhou area.

Middle Asia: includes 2 genera and 2 species. Both of them are herbage, namely *Dontostemon* and *Incarvillea*.

East Asia: includes 7 genera and 12 species. All of them are herbage which consist of *Kummerowia*, *Bothriospermum*, *Rehmannia*, *Hemistepta* and *Pinellia*.

Endemic to China: includes only one genus and one species, namely *Speranskia*. Furthermore, we classified the vascular plants into five larger types in Table 1.

From the Table 1 we may find that the flora consists of 65 Tropic genera and 114 Temperate genera, accounting for 25.90% and 45.42% respectively. Temperate genera have the overwhelming majority which demonstrates the temperate characteristics of Shandong offshore island flora. On the other hand, Tropic genera, accounting 25.69%, takes the secondary dominance in the whole flora. However the tropic genera are mainly distributed in Qingdao area. Monotypic and bitypic genera take the larger proportion in the flora of offshore islands which account for 68.32% and 30.53% respectively.

DISCUSSION

Flora history

The development history of the flora in Shandong offshore is-

Table 1. Statistics of the areal types of genera of vascular plant in offshore islands of Shandong Province

No.	Types of areal	No. of genera	Percentage (%)
1	Cosmopolitan	51	20.31
2	Tropics	65	25.90
3	Temperate	114	45.42
4	Old and general Mediterranean	20	7.97
5	Endemic to China	1	0.40
Total		251	100.00

lands was actually determined by the islands-formation and changes. The temperate zone plants take a larger proportion which account for 50%. The proportion is higher than that in Shandong province. The reason could be traced back to the connection of Shandong and Liaodong Peninsula in the ancient times and the separation situation at present. That is the reason why there is a high proportion of temperate plants. We may also say that these islands could actually be regarded as the stepping islands which play the role of bridge connecting the similarity between Liaodong and Shandong Peninsular flora (MacArthur and Wilson 1967). At the same time, some tropical species in the Zhoushan Archipelago near Zhejiang province could be found in offshore islands near Qingdao city. Therefore temperate and tropic genera take the dominance in the flora of Shandong offshore islands.

The reason of monotypic and bitypic

Monotypic and bitypic genera take larger proportion in the flora of Shandong offshore islands (up to 88.75%) which is different from the proportion of 6.4% in the flora of Shandong Province. On the one hand, the reason is caused by the heterogeneity of island habitats. The other is the epibioticity of the flora. For example, *Camellia* and *Maxhilia* in Changmenyan Island and Dagan Island could survive by now (Wang 1995).

Transmission ways of species

The plants on Shandong offshore islands could be divided into the following according to transmission channels, except the naturally distributed one.

Tide: Seeds could be transmitted to islands by the power of tide. For example, some patches of *Vitex* could be found above the tide line in the South Changshan and Heishan Island.

Ornithophilous pollination: Many plants propagated by the way of bird, which could take the seeds. Some islands were the only way of some migratory birds, which formed the profitable conditions for the exotic species to live in the islands.

Other ways: Wind affected a little in the transmission because of the distance between islands and mainland where the human activities existed. However, in some extent, the human activity influence is beyond the above mentioned ways, such as introducing exotic species and crops on purpose or carelessly. For example, some nonindigenous species have been widely distributed in Chanshan Island.

CONCLUSION

The characteristics of the flora in Shandong offshore islands are as following: Temperate characteristic is dominant in the flora of offshore islands and tropical characteristic ranks secondary. There-

fore, some islands play the role of stepping islands. 98.85% of the total genera are monotypic and bitypic genera which demonstrates the habitat heterogeneity and the great antiquity of flora offshore islands. The transmission ways mainly include tide, birds and human activities.

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