A Study on Effects of Artificial Structures on Bryophyte Diversity in Urban Greenery

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Abstract

It is important to consider urban parks and greenery not only from the viewpoint of amenity or aesthetics but also from the viewpoint of biodiversity. In this study, we focused on bryophytes (mosses), and analyzed how existence of artificial structures in urban greeney, such as concrete curbs and stone walls, affect species diversity of bryophytes. Kyoto Gyoen in Kyoto City, western Japan, was selected as the study site. In consideration of kinds of substrates on which bryophytes grow, microhabitats of Kyoto Gyoen were divided into ten types including concrete curbs and stone walls. In each type of microhabitats, we selected the area where bryophyte diversity was highest, and established a quadrat for bryophyte flora survey. Our results showed that the number of bryophyte species and growth forms and the value of diversity indices on concrete curbs or stone walls were higher than the averages of those. The bryophyte species were divided into the four groups by TWINSPAN as follows: Group A (epiphyte species), Group B (rocky species), Group C (roadsides, grassland or forest species), and Group D (waterside species). Bryophytes classified into Group B (rocky species) were mainly recorded on concrete curbs or stone walls. It was considered that the existence of artificial structures (concrete curbs and stone walls) provided favorite habitats for the bryophytes classified into Group B (rocky species), which mainly grows on concrete or rocks, and enhanced species diversity of bryophytes in Kyoto Gyoen.

Key Words : Bryophytes, Biodiversity, Artificial Structures, Urban Greenery, Urban Ecology

Ⅰ. INTRODUCTION

Conservation of biodiversity in urban areas is important because of ecological, economical, cultural importance and other reasons. Even if we protect only virgin forests where biodiversity is high, it does not lead to conservation of living things whose habitats are originally located in urban areas. Additionally, we can achieve the advantage that we easily have contact with nature. Over the past decades, several articles have been devoted to the study of conserving wildlife species in urban greenery. However, few attempts have so far been made at bryophytes (mosses). Bryophytes are so sensitive to microclimates that they are expected to reflect the characteristics of microhabitats. Therefore, to develop bryophytes habitat models in urban greenery contributes not only to bryophyte diversity conservation but also to other small wildlife diversity conservation. Ecological studies of bryophytes in urban greenery of Japan have mainly focused on their value as indicators of air quality (Taoda 1972), woodland environment (Nakamura 1981), and urbanization (Nakamura & Suga 1997) and so on. In previous study, we revealed high bryophyte diversity of the Japanese gardens from the viewpoints of bryophyte species, bryophyte growth substrates and growth forms (Ohishi & Morimoto 2003). However, in the study, little attention has been given to the effects of artificial structures because there were few artificial structures in the study area. In this study, we analyzed how existence of artificial structures in urban greenery, such as concrete curbs and stone walls, affect species diversity of bryophytes.

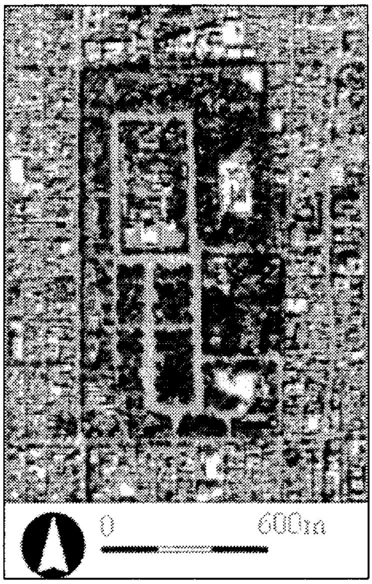

Figure 1. QuickBird satellite image of Kyoto Gyoen (DigitalGlobe November 26, 2003)


Figure 2. Kyoto Gyoen (Close View)

II. STUDY SITES

The study area was in the Kyoto Gyoen (Fig. 1, Fig. 2). Kyoto Gyoen (35° 1' N, 135° 45' E) is situated ca. 50m above sea level (Takagi, et al. 1990). The study area is warm-temperate and the potential natural vegetation is Aphanantho-Celtidetum japonicae (Miyawaki 1984). Actually, however, Pinus sp. and Prunus sp. form the main portion of the forest vegetation. Kyoto Gyoen consists of mosaic evergreen and deciduous forests, grasslands, roads, concrete curbs, stone walls and streams.

Kyoto Gyoen is located in the center of Kyoto City, western Japan. Kyoto city has warm climate with occasional light snow in winter. The average annual temperature of Kyoto City is 15.6℃, and the average annual precipitation is 1545.4mm (National Astronomy Observatory 2002).

III. METHOD

Field surveys were carried out three times in the period between December 2003 and June 2004. Compilation of bryophyte floras of each site was based on collected specimens. Most of the species identification was done by the authors, but some identifications and confirmations were requested of other experts. Nomenclature follows Iwatsuki (1991) for mosses and Fruki & Mizutani (1994) for liverworts and hornworts. All the specimens collected are kept by the authors. Bryophyte flora, growth substrates, growth forms and frequency and abundance were recorded. According to Nakamura et al. (1979), we classified bryophyte growth forms into nine types. Nakamura (1981) reported that this classification of bryophyte growth forms was related to bryophyte diversity. Nakamura (1981) suggested that bryophyte diversity increased with the number of there bryophyte growth forms. In consideration of kinds of substrates on which bryophytes grow, microhabitats of Kyoto Gyoen were divided into ten types as follows (the words in parentheses are major substrates): concrete curbs (concrete), stone walls (rocks), roadsides (soil), grassland 1 (soil), grassland 2 (decaying trees and soil), forest 1 (soil), forest 2 (decaying trees and soil), forest 3 (trunks of *Pinus* sp.), forest 4 (trunks of *Prunus* sp.), waterside (wet rocks). *Pinus* sp. and *Prunus* sp. were examined as typical coniferous trees and broad leaf trees in the study site.

In each type of microhabitats, we selected the area where bryophyte diversity was the highest, and established a 80×80cm quadrat for bryophyte flora survey except for trunks. It was impossible to establish the quadrat on trunks, so we investigated trunks of each tree to a height of 2 meters, and the number of bryophyte species and growth forms and frequency and abundance of bryophytes were recorded.

Frequency and abundance of bryophytes were measured on three scales as follows.

1 = Scarce: the species found occasionally with very low degree of coverage.

2 = Moderate: the species appearing more or less regularly with low degree of coverage or locally abundant.

3 = Abundant: the species very frequent and very abundant.

Based on the number of bryophyte species and the frequency and abundance, a two-way indicator species analysis, TWINSPAN (Hill 1979), was used to group bryophyte species and microhabitats. Pseudo-species levels for the TWINSPAN were set at 1, 2 and 3. TWINSPAN is an improvement upon the original indicator species analysis in that species are classified as well as samples, so we used this method.

Shannon's diversity index (H') and logarithmic reciprocal Simpson's diversity index (ln (1/D)) were calculated (Ito & Sato, 2002).

Table 1. The numbers of bryophyte species and growth forms and diversity indices

Microhabitats	Major growth substrates	The number of bryophyte species	The number of growth forms	H'	Ln(1/D)
concrete curbs	concrete	10	5	2.26	2.23
stone walls	rocks	9	6	2.18	2.15
roadsides	soil	10	5	2.26	2.23
grassland 1	soil	9	4	2.12	2.06
grassland 2	decaying trees and soil	8	5	2.03	2.00
forest 1	soil	7	4	1.94	1.93
forest 2	decaying trees and soil	7	4	1.93	1.92
forest 3	trunks of *Pinus* sp.	5	3	1.59	1.58
forest 4	trunks of *Prunus* sp.	9	3	2.19	2.17
waterside	wet rocks	10	5	2.28	2.23
Average		8.4	4.4	2.08	2.03

Ⅳ. RESULTS

The total number of bryophyte species recorded in this study was 39 species, including 33 species of mosses and 6 species of liverworts.

Table1 showed the number of bryophyte species and growth forms and diversity indices in each microhabitat. The number of bryophyte species and growth forms and diversity indices on concrete curbs, stone walls, roadsides and waterside were higher than the averages of those .

Figure 3 showed the division of the bryophyte

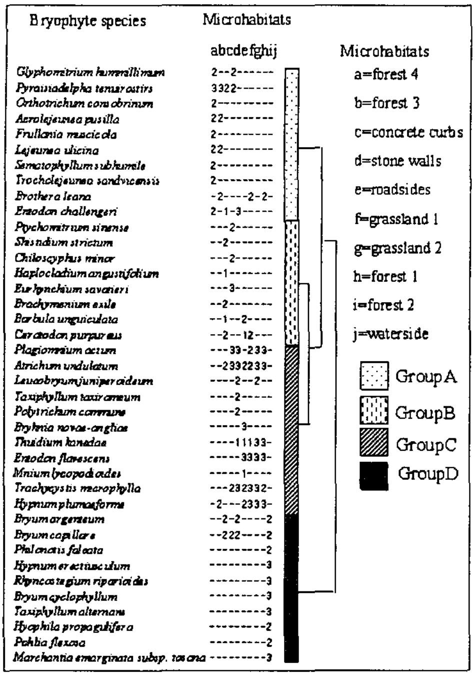

Figure 3. Division of the bryophyte the microhabitats groups produced by TWINSPAN

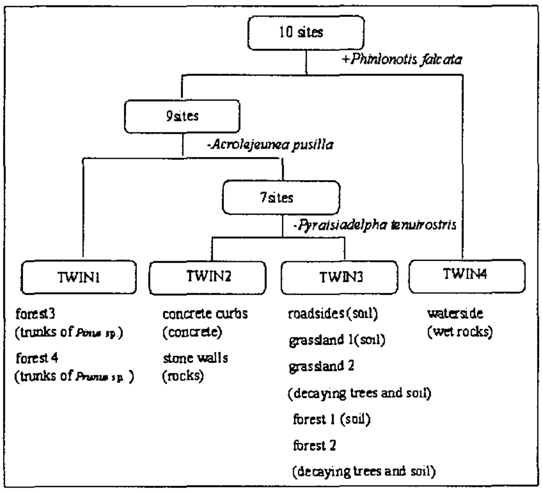

Figure 4. TWINSPAN hierarchy of sites based bryophyte species

groups and the microhabitat groups produced by the TWINSPAN. According to the results of TWINSPAN, we divided the bryophyte species into four groups as follows : Group A (epiphyte species), Group B (rocky species), Group C (grassland or forest species) and Group D (waterside species). Group A consisted of bryophyte species mainly growing on trunks. Group B clustered bryophyte species mainly growing on concrete or rocks. Group C consisted of bryophyte species of roadsides, grasslands or forest floors. Group D clustered bryophyte species of waterside.

TWINSPAN also split the ten types of microhabitats into distinct four groups as follows (Figure 4): TWIN1 (tree trunks), TWIN2 (artificial structures), TWIN3 (roadsides, grasslands and forests) and TWIN4 (waterside). TWIN1 consisted of microhabitats characterized by tree trunks (trunks of *Pinus* sp. and *Prunus* sp), TWIN2 clustered microhabitats characterized by artificial structures (concrete curbs and stone walls), TWIN 3 consisted of microhabitats in roadsides, grasslands and forests (roadsides, grassland 1, 2 and forest 1, 2) and TWIN4 clustered microhabitats marked by waterside.

Indicator species separated by means of TWINSPAN were *Philonotis falcate*, *Acrolejeunea pusilla* and *Pyraisadelpha tenuirostris* (Figure 4).

Table 2 showed the relationships between Group A to D and TWIN 1 to 4.

Table 2. The species numbers of bryophyte groups (Group A to D) recorded in the microhabitats groups (TWIN 1 to 4)

	GroupA	GroupB	GroupC	GroupD
TWIN1	10	0	1	0
TWIN2	3	8	2	2
TWIN3	2	2	11	2
TWIN4	0	0	0	10

V. DISCUSSION

The numbers of bryophyte species and growth forms and the diversity indices on TWIN2 (artificial structures) were higher than the averages of those

(Table 1). The bryophytes classified into Group B (rocky species) were mainly recorded in TWIN2 (artificial structures) (Table 2). These results indicated that TWIN2 (artificial structures) provided favorite habitats for bryophytes, in particular, for the bryophytes classified into Group B (rocky species), and enhanced species diversity of bryophytes in Kyoto Gyoen.

Concrete curbs and stone walls (TWIN2) uncovered with leaf-fall and weeds were considered to be suitable habitats for bryophytes classified into Group B (rocky species). The reason was that leaf-fall and weeds obstructed bryophyte growth (Ohishi & Morimoto 2003).

Table 1 showed that the bryophyte diversity of the roadsides and waterside was higher than average of those too. Soil on roadsides and wet rocks on waterside were uncovered with leaf- fall and weeds. In addition, many bryophyte species prefer to grow on waterside (Girbert 1955). Therefore, roadsides and waterside were considered to be suitable habitats for bryophytes.

Concrete curbs and stone walls (TWIN2) were also considered to provide habitats for some bryophyte species classified into Group A, B and D (Table 2). Some bryophyte species classified into Group A, B and D can grow on concrete, rocks and soil on concrete or rocks. Stone walls create conditions of shade and damp, providing microhabitats for bryophytes which grow on soil in the crevices.

We revealed the high bryophyte diversity on concrete curbs and stone walls (TWIN2) from the viewpoints of the species richness, growth form type variety and species diversity indices. In particular, these artificial structures enhanced the diversity of bryophytes classified into Group B (rocky species).

Therefore, existence of artificial structures such as concrete curbs or stone walls was considered to contribute to the diversity of bryophytes in urban greenery.

There is room for further investigation of the relationships between bryophyte diversity and environmental conditions.

Ⅵ. ACKNOWLEDGMENTS

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