Relationship between Vegetation, Water Environment and Microtopography in a Warm-Temperate, Volcanic Peat Mire in South-Western Japan

Yoshiumi SHINOHARA* and Tsutomu IYOBE
Graduate School of Environmental Engineering, The University of Kitakyushu,
1-1 Hibikino, Wakamatsu-ku, Kitakyushu 808-0135, Japan
* Corresponding author: curious.challenger@gmail.com

Abstract

Relationships between vegetation and soil chemical environment were studied in Tadewara mire, a volcanic mountainous mire in Kyushu, south-western Japan, with reference to their change in two years. Hydrology and water chemistry of habitat were analyzed with relation to establishment of vegetation and vegetation change in this mire. High species richness of site related to low groundwater table, low electrical conductivity and high pH of the habitat. Vegetation change at sites with low pH, high groundwater table, and high electrical conductivity was small.

Keywords: mire, electrical conductivity, pH, groundwater table, relative elevation

Introduction

The Tadewara mire have peat affected by volcanic activity (Nakazono *et al*. 2008), which located in Ohita prefecture, Japan. Distribution of peatlands in warm-temperate zoon is limited to some mountainous region in south-western Japan (Wolejko *et al*. 1986). The Tadewara mire and the Bougatsuru mire are located in the Aso volcanic area and these mires are the habitat of 51 endangered plant species (Arakane *et al* 2002). Hydrology and water chemistry of habitat are important factors for determining vegetation in peatlands (Wheeler et al. 2000, Asada 2002). However, relationships between vegetation and environmental condition has not been fully studied especially in the volcanic mires.

In this study, we investigated the correlation between vegetation and environmental condition in a volcanic mire. We specially noticed to the change in vegetation and environmental parameters in soil and discussed the direct effect of environmental change on mire vegetation.

Methods

(1)Study site

The study site was located in Tadewara Mire (33°06’N 131°15’E, area of 40 ha, altitude of 1050m a.s.l.; Fig.1). The mire is dominated by *Phragmites australis* Cav (Trin) ex Steud., *Moliniopsis japonica* (Hack.) Hayata., *and Miscanthus sinensis* Anderss (Arakane 2002). Annual mean temperature between 1971 and 2000 was 9.5°C. The coldest month is January and the mean monthly temperature is -1.8°C. The warmest month is August and the mean monthly temperature is 21.0°C (Japan meteorological agency 2001). Annual mean precipitation is 3000mm (Japan meteorological agency 2002).

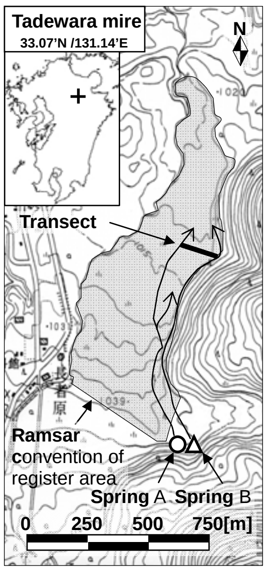

Fig. 1 Study site
(C) Geographical Survey Institute

(2)Field survey

A survey transect line of 160m long was established on the centre of mire with well developed peat of bog vegetation. This line was located between two streams in the mire those originated from springs at the south-eastern end of the mire. The surveyed area was dominated by *M. japonica*, *Sphagnum palustre* L., *Sphagnum fimbriatum* Wils. In Hook, *Hydrangea paniculata* Sieb. et Zucc. *and P. australis*. A total of seventeen sites of 1m×1m were placed along the transect line at 10m intervals. A polyvinyl chloride pipe of 1.3m long and 0.38m outside diameter with holes at four directions at 10cm intervals was inserted vertically until the pipe reached 90cm depth at 10 m intervals on the line transect.

(3)Vegetation, groundwater table, water chemistry and microtopography

Vegetation was recorded on 30 and 31 July 2007 and 10 and 11 July 2008. One hundred sixty quadrats of 1m×1m were placed along transect line at 1m intervals. Coverage of all the species present in each quadrat was recorded.

At each of the pipe, groundwater table was measured 17 times from 10 August 2006 to 24 July 2008 at monthly. However measurement was made at four month intervals from 21 July 2007 to 16 November 2007 and from 27 January 2008 to 23 May 2008, measurement was made at two month intervals from 16 November 2007 to 27 January 2008. Water table depth was measured as the distance from the ground surface to groundwater table in each pipe.

On the same day of the water table depth measurement, water samples were collected from each of the pipe, and stored in 100ml polyethylene bottles. The pH and electrical conductivity of all water samples were measured within 12 h after collection.

Microtopography was measured on 13 June 2008 as relative elevation along transect at 1m interval relative to the level at western edge of the transect.

(4)Data analysis

Vegetation was classified into four types by presence or absence of species in each quadrat in 2007 and 2008. Species were categorized as four types at each of the quadrat. Species that presented both in 2007 and 2008 was classified as '3'. Species that presented in 2007 and was absent in 2008 was classified as '2'. Species that was absent in 2007 and presented in 2008 was classified as '1'. Species that was absent both in 2007 and 2008 was classified as '0'. Quadrats were grouped by two-way indicator species analysis (TWINSPAN; Hill *et al.* 2005) by using species number defined as above. Cut lever were set at 0.5, 1.5 and 2.5. Except for cut level, the TWINSPAN computer program (TWINSPAN for Windows version 2.3.) was run using the default option.

The pH was converted to value of H^+ ion concentrations before the calculation of mean. Mean of electrical conductivity, pH, groundwater table depth and relative elevation measured at each quadrat during the study period were compared among groups classified by TWINSPAN. Statistically significant difference in these environmental parameters were tested by using Tukey-Kramer Test ($p<0.05$).

Results

Four groups (group A-D) of quadrats were recognized by the second division of TWINSPAN (Fig. 2). Group A was located mainly between 3m and 21m on the transect line. Group B was located mainly between 34m and 106m on the transect line. Group C was located mainly between 134m and 144m on the transect line. Group D was located mainly between 152m and 160m on the transect line.

Mean total number of species in each quadrat in 2007 and 2008 was highest in group D (12.2 spp.), and was lowest in group B (3.77 spp). Mean number of immigrated species in each quadrat between 2007 and 2008 was highest in group D (5.40 spp.), and was lowest in group B (0.31 spp.). Mean number of distincted species in each quadrat between 2007 and 2008 was highest in group C (1.41 spp.), and was lowest in group B (0.14 spp.). Mean number of species those presented both in 2007 and 2008 was highest in group C and D (6.80 spp.), and was lowest in group B (3.46 spp.).

Mean electric conductivity was highest in group B (32.3 mS/m), and was lowest in group C (14.2 mS/m, Fig.3-a). Mean pH was highest in group C (pH 5.65), and was lowest in group B (pH 4.25, Fig.3-b). Mean of water table depth was highest in group B (0.3 cm), and was lowest in group C (12.6 cm, Fig.3-c). Mean of relative elevation was highest in group C (relative elevation 127.1cm), and was lowest in group D (relative elevation 69.7cm, Fig.3-d).

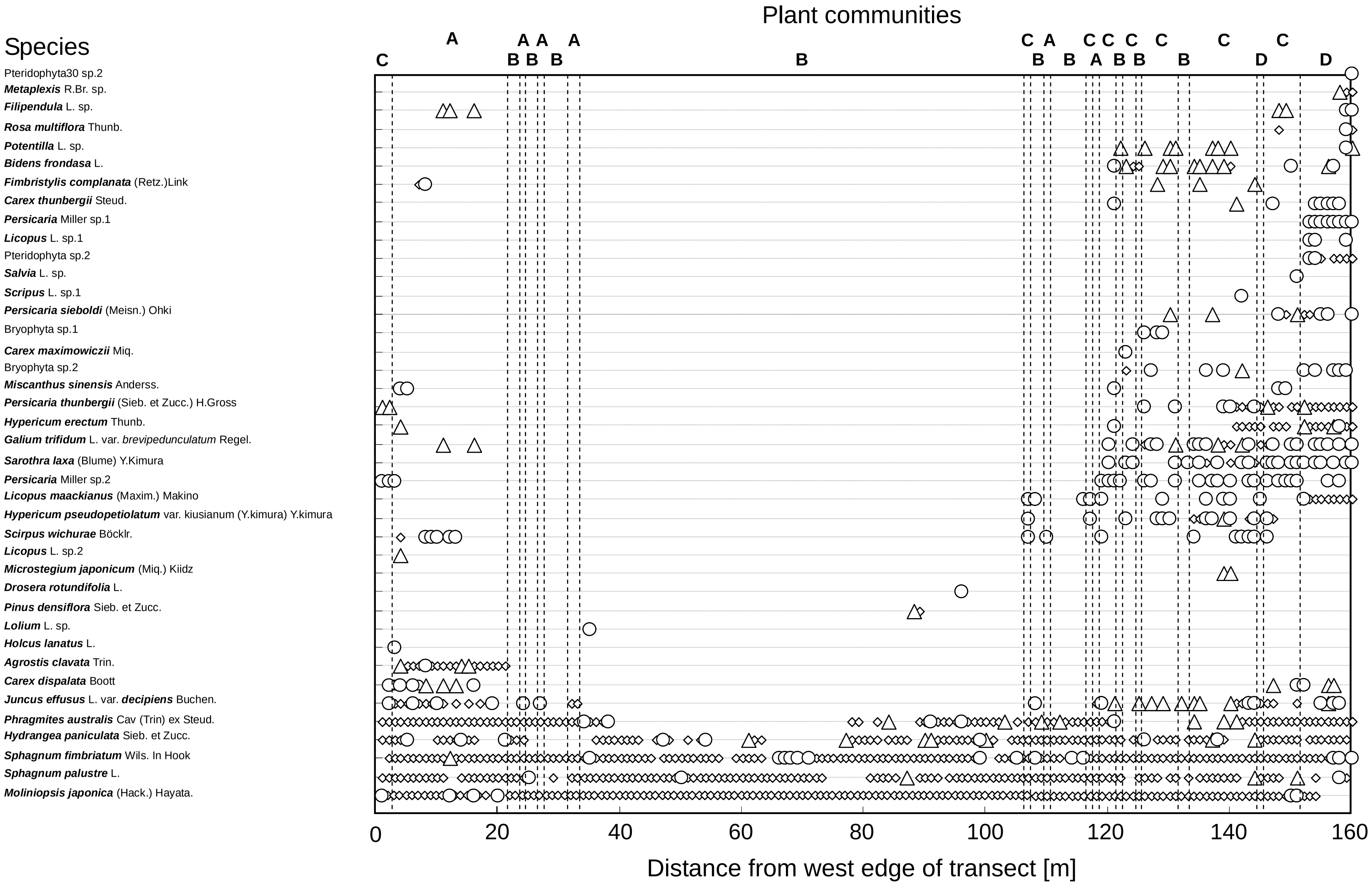

Fig.2 Distribution and appearance of species on the transect line. Quadrats were classified into groups (A-D) by TWINSPAN. Symbols:◇, presented both in 2007 and 2008; ○,presented in 2007 and was absent in 2008; △, absent in 2007 and was presented in 2008;

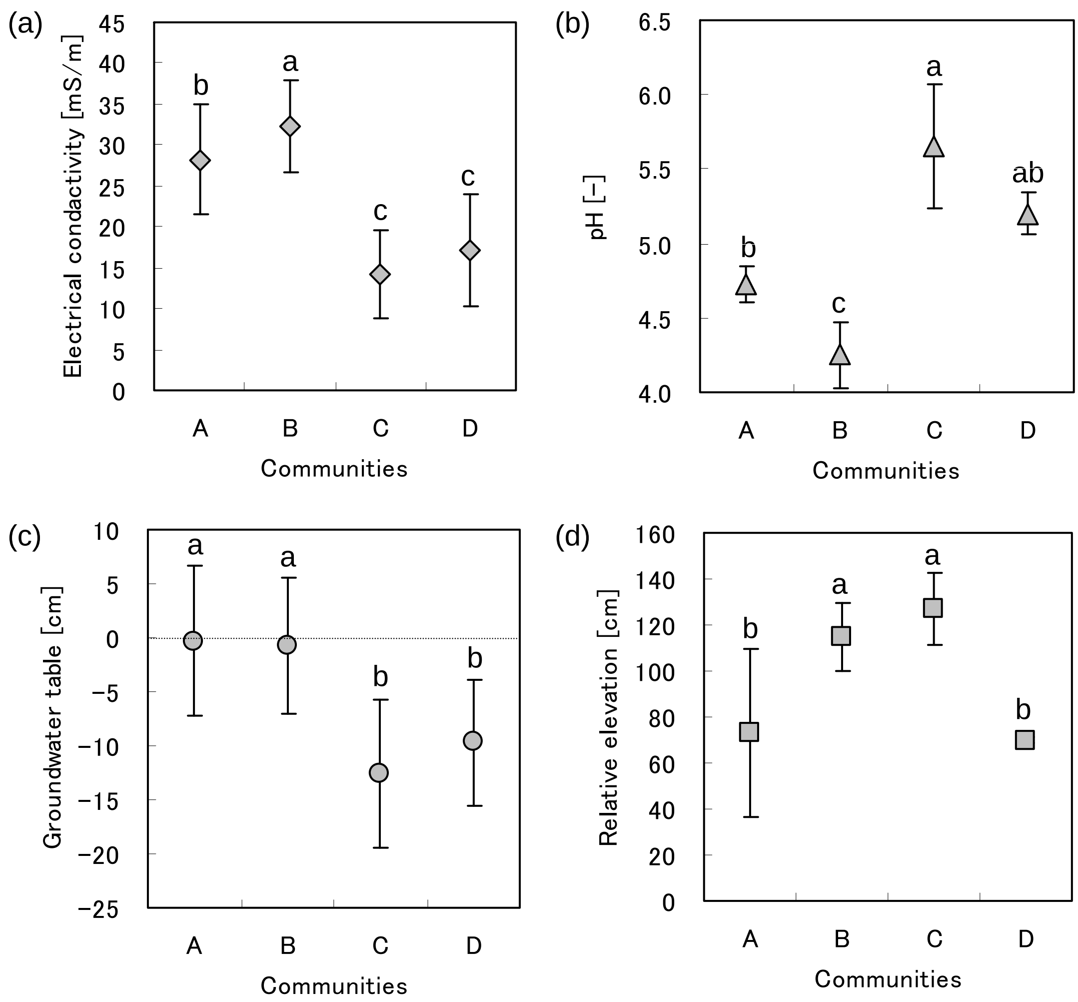

Fig. 3 (a) Averaged electrical conductivity, (b) pH, (c) groundwater table and (d) relative elevation among groups classified by TWINSPAN using presence or absence of species in 2007 and 2008 (see text). Vertical bars indicate standard variation. Means sharing the same letter are not significantly different by Tukey-Kramer Test, ($p<0.05$).

Discussion

M. japonica, *S. palustre*, *S. fimbriatum*, *H. paniculata and P. australis* dominated in all of the groups especially in group B. Total number of species as well as immigrated species number were low in group B. Electrical conductivity and groundwater table in group B were high, and pH was low. In contrast, group D had high number of total species and immigrated species. *Carex thunbergii* Steud., *Persicaria* Miller spp., *Galium trifidum* L. var. *brevipedunculatum* Regel, *Sarothra laxa* (Blume) Y. Kimura immigrated to sites in group D in 2008. Electrical conductivity and groundwater table in group D were significantly lower, and pH was significantly higher than group B. Electrical conductivity, pH and groundwater table were thus the distinguishing environmental parameters between group B and D.

Salvia L. sp., *Scripus* L. sp1., Bryophyta sp1., *Carex maximowiczii* Miq., *Miscanthus sinensis* Anderss., *Scripus wichurae* Böcklr. immigrated to sites in group C in 2008. These species did not appear in sites in group D in 2008. Pteridophyta sp.2, *Persicaria* sp.1, *Licopus* L. sp.1, Pteridophyta sp.1, immigrated to sites in group D in 2008. These species did not appear in sites in group C in 2008. Except relative elevation, electrical conductivity, pH and groundwater table were not significantly different between groups C and D. Relative elevation in group C were significantly higher than group D. Relative elevation was thus the distinguishing environmental parameters between groups C and D.

Abundance of *Scripus wichurae*, *Miscanthus sinensis* and *Holcus lanatus* L. increased at sites in group A in 2008, whereas these species did not appear in sites in group B. *Drosera rotundifolia* L. and *Lolium* L. sp. immigrated to sites in group B in 2008, whereas these species did not appear in sites in group A. Groundwater table were no significantly different between groups A and B. Electrical conductivity and relative elevation in group A were significantly lower, and pH was significantly higher than group B. Electrical conductivity, pH and relative elevation were thus the distinguishing environmental parameters between groups A and B.

Fimbristylis complanata (Retz.) Link, *Holcus lanatus* and *Agrostis clavata* trin. appeared in sites in group A in 2008, whereas these species did not appear in sites in group C in 2008. Bryophyta sp.1, *Carex maximowiczii*, Bryophyta sp.2, *Galium trifidum*, *Sarothra laxa*, Licopus maackianus (Maxim.) Makino and *Hypericum pseudopetiolatum* var. kiusianum (Y.kimura) Y.kimura were increased in site in group C in 2008, whereas these species were not grown to sites in group A in 2008. Abundance of *Miscanthus sinensis*, *Persicaria Miller* sp.2 and *Scripus wichurae* increased in sites in group A and C in 2008. Licopus L. sp.2 disappeared at site in group A in 2008, whereas these species did not appear in sites in group C both in 2007 and 2008. *Potentilla* L. sp. and Fimbristylis complanata disappeared at sites in group C in 2008, whereas these species did not appear in sites in group A both in 2007 and 2008. Abundance of *Bidens frondasa* L., *Persicaria sieboldi* (Meisn.) ohki, *Microstegium japonicum* (Miq.) Kiidz and *Juncus effusus* L. var. *decipiens* Buchen. decreased in sites in group C in 2008. Electrical conductivity and groundwater table in group A were significantly higher, and pH and relative elevation were significantly lower than group C. Electrical conductivity, pH, groundwater table and relative elevation were thus the distinguishing environmental parameters between groups A and C.

Abundance of *Fimbristylis complanata*, *Miscanthus sinensis*, *Holcus lanatus* increased in sites in group A in 2008, whereas these species did not appear in sites in group D in 2008. Pteridophyta sp.1, *Fillpendula* L. sp., *Carex thunbergii*, *Persicaria* sp.1, *Licopus* sp.1, Bryophyta sp.2, *Sarothra laxa* immigrated to sites in group D in 2008, whereas these species did not appear in sites in group A in 2008. Electrical conductivity and groundwater table in group A were significantly higher than group D. The value of pH and relative elevation were not significantly different between groups A and D. Electrical conductivity and groundwater table were thus the distinguishing environmental parameters between group A and D.

Drosera rotundifolia L. and *Lolium* L. sp. immigrated to sites in group B in 2008, whereas these species did not appear in sites in group C. *Salvia* sp., *Scripus* sp.1, Bryophyta sp.1, *Carex maximowiczii*, *Miscanthus sinensis*, *Scripus wichurae* immigrated to sites in group C in 2008, whereas these species did not appear in sites in group B. *Filipendula* L. sp., *Potentilla* L. sp. and *Fimbristylis complanata* disappearted at sites in group C in 2008, whereas these species did not appear in sites in group B both in 2007 and 2008. Abundance of *Bidens frondasa* L., *Persicaria sieboldi* (Meisn.) ohki, *Microstegium japonicum* (Miq.) Kiidz and *Juncus effusus* L. var. *decipiens* Buchen. decreased in sites in group C in 2008. Electrical conductivity and groundwater table in group B were significantly higher, and pH was significantly lower than group C. Relative elevation were not significantly different between groups B and C. Electrical conductivity, pH and groundwater table were thus the distinguishing environmental parameters between groups B and C.

Environmental condition of low pH, high electrical conductivity and high groundwater table could limit species change in group B. Environmental condition of high pH, low electrical conductivity and low groundwater table could not limit species change in groups C and D.

Acknowledgement

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