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THE MANAGEMENT OF RIVERBANK MAINTAINS THE DUNE PLANT POPULATION, AN ENDANGERED SPECIES, *FIMBRISTYLIS SERICEA*

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ABSTRACT: The habitat of riverbank dune nurses several endangered species. Why did this area maintaine endangered species despite of invasion of alien species? Then growth of an endangered species (*Fimbristylis sericea*) and an alien species (*Diodia teres*) was studied in a greenhouse experiment in which the species were grown alone or together and the resultant effects of shoot and root competition were assessed. In the alone growth experiment, the survival rates of the both species were same. In the shoot competition experiment, the *D. teres* reduced growth rate of *F. sericea*. In the root competition experiment, the *F. sericea* reduced growth rate of *D. teres*. In the total competition, *F. sericea* were superior to *D. teres*. From the experiments, *F. sericea* was more competitive than *D. teres* under the waterless same habitat. *D. teres* was more competitive than *F. sericea* under the waterrich condition. The habitat of riverbank dune is always affected strong wind, than the disturbance of sand moving. When *D. teres* is grown up, the sand moving prevented growth of *D. teres*. In the long term, the vegetation succession will reduce the disturbance frequency and will be occurred the extinction of endangered species.

Keywords: Endangered species, Alien plants, Riverbed dune, Water condition, Organic matter

1. INTRODUCTION

In Japan, dune vegetation and its endemic species are now in danger of extinction. Not more than a hundred years ago, it was not difficult to find extensive sandy beaches with huge dunes along the seashore. Like many other natural ecosystems, however, the area and number of extensive sandy beaches covered by typical dune vegetation had considerably decreased with the advance of modernization [1]. Especially the riverbank dunes are almost disappeared except Kiso river. There were mainly 3 riverbank dunes in Japan from some papers that reported about riverbank dune [2]-[4]. The dunes of Tone River and Kitakami River have been covered with vegetation, we cannot see the dune anymore except for Sobue dune in Kiso River.

Sobue dune allocated 25km from the mouth of Kiso River. Sobue dune have been maintained by the strong wind from the mountains and sand from the river stream. Furthermore, artificial disturbances are very important at Sobue dune. Athletics, a forest and a water sports place are maintained in the site, and such as the Bon dance is held, Sobue dune bustles with many people through a year. Especially disturbance by bulldozers has been done for the sand festival from 1990. The sand dune environment is maintained, there are many kinds of endangered species *Chenopodium virgatum*, *Fimbristylis sericea*, *Artemisia capillaris* and so on. These plants have drying stress tolerant and regenerative power from the sand buried [5]. Therefore, sand dune vegetation peculiar to a sand dune is formed [1]. Further hard wind condition humus derives from organic matter at a sand dune. But it's little and scarce in the natural provision of the fertilizer components [5]. There are almost no cases that a plant specialized in adaptation to such sand dune environment goes into the environment besides the sand dune.

Recently some alien plants have invaded into the sand dunes [6]. Alien plants affected the growth of native plant and prevent the reproduction [7]-[9]. Alien species can easily invade in riverbed dune because Sobue sand dune is located near the city, and the disturbance frequency of Sobue dune is so high that invasion is easily petmitted.

F. sericea is endangered species in Japan. Their distribution is mainly on a coast in western Japan. The habitat of the species is only dune, so the area of the habitat will be smaller and smaller because of the human construction. The Sobue dune is rare habitat of the *F. sericea*. It's important to know what kind of influence of maintenance mechanism in a sand dune is having on an endangered plant species.

It's necessary to do a measure of maintenance of the sand dune area, prevention of planting trees and an extermination of alien species in preservation of the sand dune environment. In this study, we focused on the relationships between the ecology of

F. sericea and sand dune condition. The methods of endangered species conservation are proposed from the angle of river management on it. The purpose of our study is to find what kind of river management is useful for conservation of endangered species.

We have three hypothesis, 1)The dune condition is very dry and cannot maintain water, 2)the dry condition is very convenient of *F. sericea* because they have dry stress tolerant, 3)the light condition is very important for the species. It was paid attention to the three points and analyzed.

2. MATERIALS AND METHODS

2.1 The Study Site

The study was carried out on the left riverside of Kiso River at Aichi Pref. (North 35°15′48″, East 136°42′19″), the middle of Japan. The area has been managed as wild nature plaza that called "Sario Park Sobue". In the Park there are some ecotone along the sand dune, river bed forest, low grassland and bare land. The area was divided 4 plots along with the vegetation types. The vegetation cover percentage of Plot A was under 10%, plot B was from 10 to 50%, plot C was from 50 to 80% and plot D was over 80% (Fig. 1).

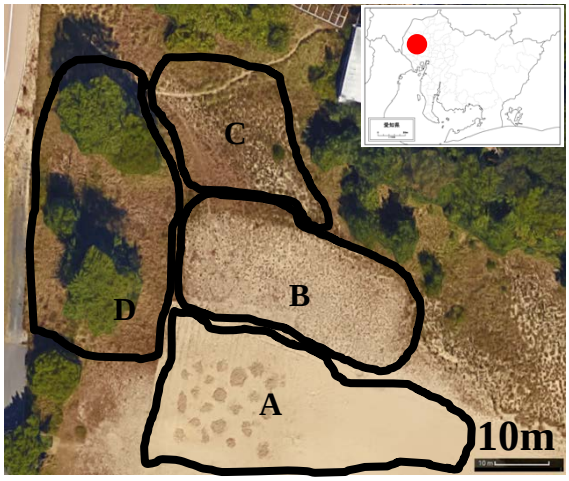

Fig.1 The vegetation cover of each plots.

2.2 The Study Plant

Fimbristylis sericea (CYPERACEAE) is a perennial grass in sand habitat along the coast (Fig. 2-A). The species distributes from East Asia to South of Australia. The habitat of *F. sericea* is dry open sand condition, that is very rare habitat in Japan for the reason of dams and harbor construction and so on. Regardless rich number of individual, only four populations of the species observed in Aichi Pref., so the species was endangered species rank Vulunerable (VU) in Aichi Pref.

Diodia teres (RUBIACEAE) is annual plant introduced from North America in 1920's (Fig.2-B). The species is ruderal and strong competitor at the river bed and sea shore. It has long stems, and lean and covered with other species. Recently many river and coast endangered species are affected by the species.

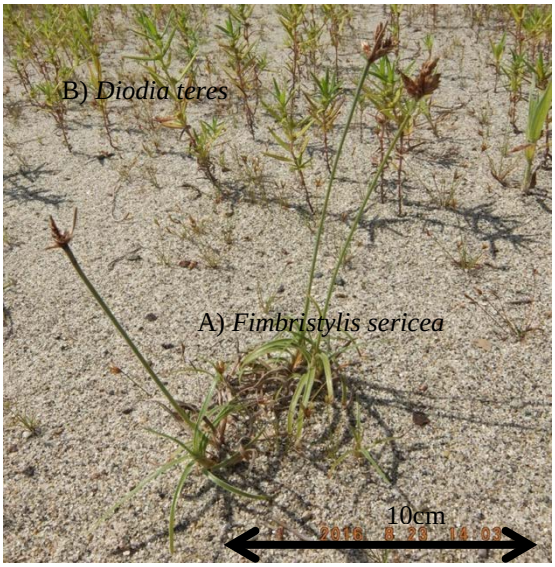

Fig.2 Photograph of *F.sericea and D. teres*.

2.3 Environmental Condition Measurement

To measure the capacity of retained water in each plot, the soil samplings were done on 28th April (rainfall over 10mm), 29th (no rainfall) and 30th (no rainfall), 2016. Core sampling size was 60 mm in diameter and 45 mm in high. 10 cores were collected in each plot on every three days. The weight of fresh core samples were measured immediately. After drying in the drying machine (100ºC 24hr), dried core samples were measured. The water content of core samples was calculated as (fresh weight (g) – dry weight(g))/dry weight(g). Furthermore, dried cores were burned in the muffle furnace (1000ºC 24hr) to measure loss on ignition. The loss on ignition was calculated (dry weight(g) - burn weight(g))/burn weight(g). To detect the difference among plots, Shapiro-Wilk test for the distribution check and Wilcoxon rank sum test were used on non-normal distribution, and t-test were done on normal distribution.

2.4 Competition Experiment

Four conditions were prepared to measure the competition between *F. sericea* and *D. teres*. First condition was single cultivate, second was competition between roots, third was upper side,

forth was total competition (Fig 3). Each pot (9cm diameter 12cm hight) was filled with 50ml volcano ash soil and 200ml sand as the habitat of *F. sericea* with low nutrient and water. This experiment done from 19th June to 27th July in 2016 in open area. Watering was performed every 2 days to prevent dry up. Every week the survival rate was counted, and measured leaf number (LN) and leaf length (LL)(mm) on *F. sericea*, diameter of stem (DS)(mm) and height (DH) (cm) on *D. teres* to measure the growth four times.

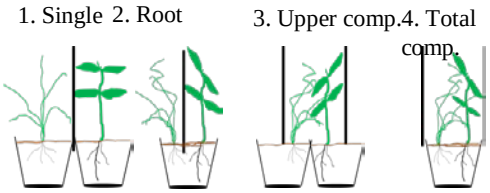

Fig.3 Conditions of four competition

2.5 Comparison of Growth

Fifteen *F. sericea* and 26 *D. teres* were collected to measure the expect dry weight (DW) of plants. It was measured about collected plants that leaf number and leaf length at *F. sericea*, diameter of stem and height at *D. teres*. Then each plants were dried (100°C 24hr). From the data, the regression was lead out, expected weight of plants was calculated.

3. RESULTS

3.1 Water Condition

About the water contents on rainy day, there was no differences among the plots. But the decrease curve of the water condition was different among the plots. The distributions of each plot on 30th were normal distributions. Then the pairwise tests were done between two plots, there was a significant difference between plot A and plot D. Fig. 4 shows the water condition curve in each plot. Plot D had the high ability of water maintenance, and Plot A is the most severe condition about water than the other plots.

The loss on ignition at each plot were shown in Fig. 5. The loss on ignition was related to the vegetation cover rate. That of plot D was the highest in all plots. The nutrient of plot A was low for the shortage of organic substance. Though the distributions of plot A, B, D were normal, that of plot C is non normal. Then nonparametric test (Wilcoxon rank sum test) was done at plot C. There were significant differences between plot C and other plots ($P<0.001$). Welch t-test was done at other plots. There were significant differences between plots ($P<0.001$).

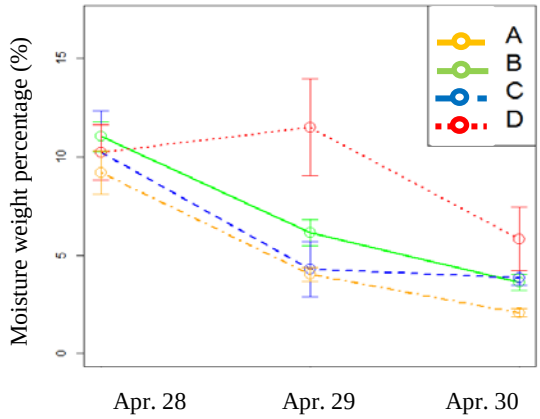

Fig.4 The water loss curve of each plots after rainfall

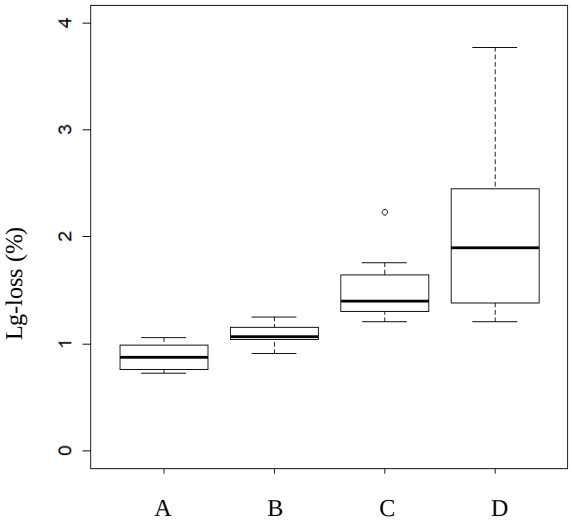

Fig. 5 The loss on ignition in each plot

3.2 Competition Experiment

Fig. 6 showed the survival ratio in each competition. At the value of the single competition there was no difference between two species. But *D. teres* was superior to the *F. sericea* at upper part competition. At root competition and whole competition *F. sericea* was superior to *D. teres*. Light condition is most important for the *F. sericea* than the water condition.

Fig. 7 showed the regression of the relationships between the dry weight and LLxLN at *F. sericea* and the relationships between the dry weight and DSxDH. The model of the dry weight at each measurement were Eq. (1) at *F. sericea* and Eq. (2) at *D. teres*.

$$DW(mg) = 0.0003 \times LN \times LL - 0.0061 \quad (1)$$
$$DW(mg) = 0.0009 \times DS \times DH + 0.0045 \quad (2)$$

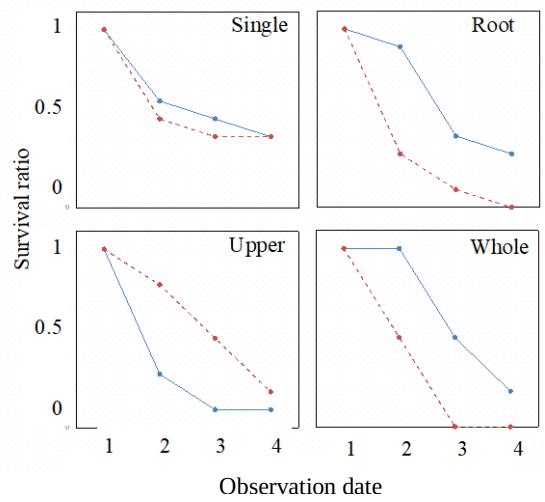

Fig. 6 The survival ratio at each competition (solid line was *F. sericea*, dotted line was *D. teres*). Single: no competition, Root: upper part was separated, root was same pot, Upper: upper part competition with each pot, Whole: growth in same pot and no separation upper part

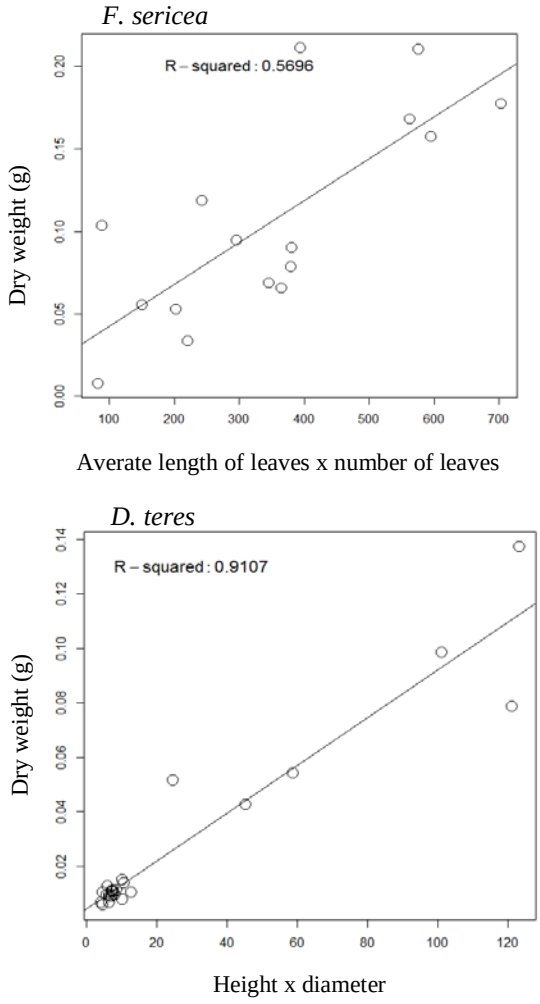

Fig. 7 The regression of the model in each species

Fig. 8 showed the growth ratio at each competition using Eq.(1) and Eq(2). There was differences between two species at each competition. At the no competition and upper competition, the growth ratio of *D. teres* was higher than that of *F. sericea*. On the other hand, at the root competition and total competition, the growth ratio of *F. sericea* was superior to alien species.

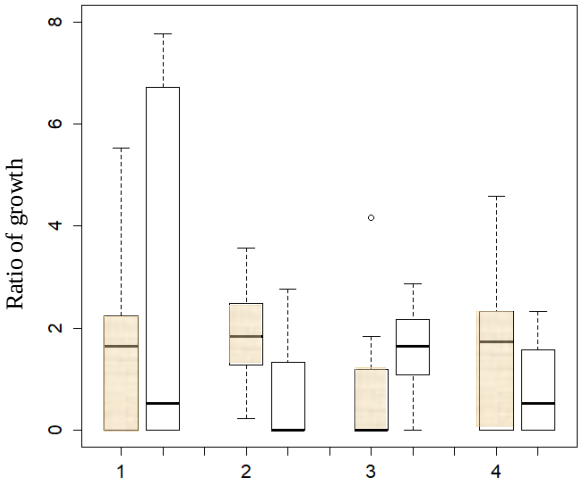

Fig.8 The growth ratio of two species (hatched distribution: *F. sericea*, white distribution: *D. teres*) at each competition (1: single growth, 2: root competition, 3: upper competition, 4: total competition)

4. DISCUSSIONS

Form our research, it was revealed that the ecology of the *F. sericea* was adapted dry and oligotrophic condition. The physiology of the species was the character of dune plants [10]-[12]. For sufficient temperature and precipitation, the vegetation succession was occurred in all over Japan. Especially river environment has been stable for the dam and soil erosion control work construction [13][14]. The condition of the dune was destroyed by the vegetation succession. When the succession promotes, the water condition was changed and the nutrient supply occurred. The habitat of the *F. sericea* has been reduced from the river control. The Fig. 9 showed the condition of the Sobue dune used by CSR-triangle [15]. Plot A is the most severe condition for the plant, and *F. sericea* is suit to the condition.

Now the invasion of alien plants is serious problem in the river system [8][9]. But *D. teres* cannot invade the dune condition where the water and nutrient supply was not sufficient as other species, *Miscanthus sinensis* and *Imperata cylindrica* [16][17]. The native species *F. sericea* was superior to the strict condition. If the succession began, the light condition would be worse and the

reduction of the distribution occurred. The light condition is another problem of sand area plant species. The artificial disturbance of the Sobue dune is very important for the endangered species.

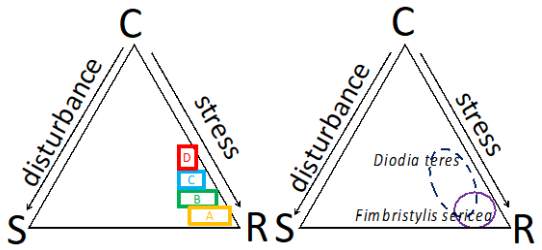

Fig. 9 The condition of the Sobue dune at CSR triangle (C: competitor, R: ruderal, S: stress tolerant strategy)

The manager of Sobue dune is faced the financial crisis to maintain the dune. The cost of bulldozer to maintain the dune is almost two million yen per year. The manager wants to cut off the cost. And some nature conservation groups call for the halt to the disturbance by bulldozer for other animals.

For the biodiversity, it will be very good condition that many kinds of vegetation are maintained in the Park. Around Sobue dune, there are many kinds of biomes, like river bed dune, low grassland, dune, wetland, and so on. For other animals there are many places prepared. The succession is proceeded, it becomes all same vegetation, the unification advances. It is necessary to maintain the dune for the biodiversity.

The biodiversity has been reduced by the construction, the cost should be needed to maintain the biodiversity for the mitigation. And our research confirms the merit of the endangered species about the disturbance. The invasion of alien plants will be prevented by the disturbance. The manager of the Sobue dune has contributed to the maintenance of the biodiversity.

5. CONCLUTION

The following conclusions are drawn based on the study:

1) river dune condition is very strict for plants, because there are few water and nutrient for the sand as seashore dune, 2) *F. sericea* is stress tolerant about water stress and lack of nutrient, beside light condition, 3) light condition is very important for the species because *F. sericea* lost at the competition to the other taller plants, 4) *D. teres* (alien plant) cannot invade into the dune condition.

Based on the conclusion, three proposals about the management method of the disturbance, 1) the disturbance should be done before winter in order to release the nutrient matter from the sand, 2) the disturbance should be done in the area where the alien plants invaded, 3) the cost of the disturbance must be needed for the construction to maintain the biodiversity for the mitigation.

6. ACKNOWLEDGEMENTS

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