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STRUCTURE AND SUCCESSION OF ALPINE PERENNIAL COMMUNITY (*POLYGONUM CUSPIDATUM*) ON MT. FUJI

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Abstract: Successional process of herbaceous perennial was investigated on the alpine zone of Mt. Fuji. The study site is located at the timberline of the southeast slope where it is mainly covered by various growing types of *Polygonum cuspidatum* patch. The structure of these patches was studied in relation to the successional stage of the alpine timberline. Measurements of shoot height, density of shoots, biomass above the ground and soil nutrient condition were carried out in patches of various sizes. The biomass of large, medium and small patches was 3400, 970 and 120 g, respectively. In the central part of the large patch, a low density and low biomass area (dead center) existed, and where other species have invaded. These various-sized patches play a significant role in the successional process on the alpine zone.

1. Introduction

The plant community in the vicinity of the timberline of Mt. Fuji is not in a stable climax stage, but in one of the currently advancing successions (HAYATA, 1911; TOHYAMA, 1968; MASUZAWA, 1985). On the southeast side, bare land and communities of perennial herbaceous plants are widely distributed over an area extending downward from the vicinity of the Hoei Crater (MASUZAWA, 1985). In such circumstances, herbaceous perennial communities play an important role in the process of succession to a woody plant community. That is, in almost all cases on Mt. Fuji, the transfer from alpine grassland to forest starts with the invasion of woody plants into patches of *P. cuspidatum* and *P. weyrichii*. Therefore, it is assumed that these *Polygonum* patches offer a "place" in a process where woody plants can be stabilized.

This paper reports an initial investigation of the structure of *P. cuspidatum* patches. The process of successional advance promoted by these patches is discussed, based on a pattern of structural change as indicated by data on patch size, population, and biomass.

2. Study Area and Methods

Mount Fuji (3776 m alt.) is the highest peak in Japan, located near the southern coast of the central part of Honshu. Most part of its slope is covered with various types of vegetation up to a height of about 2500 m above sea level, except for a part of the southeastern slope where the vegetation is in the process of recovery from damage by the latest volcanic eruption from Hoei-Zan, a parasitic crater, in 1707 AD.

In general, the timberline forms on Mt. Fuji at 2400 to 2500 m above sea level. The study area (35°21′N, 138°54′E) is situated at the timberline on the southeastern side at 2400 m above sea level, in an area formed by the slope of the secondary crater, Hoei-Zan. *P. cuspidatum* and *P. weyrichii* dominate on this slope and only the small numbers of seedlings of woody plants are present. A quadrat of 2500 m^2 (50 m × 50 m) was arranged at the site, within which a representative test patch of *P. cuspidatum* was selected for each of three general patch sizes: large, medium, and small. The height and number of shoots, the density and the biomass were then investigated, with the structure of each test patch. A belt transect method was adopted, with belts set from the upper side to the lower side of each patch.

The dry weight of the shoots in each patch was determined after drying at 80°C. Soil was collected from one each site in the central and peripheral parts of the medium test patch. After the soil samples were air-dried, and the gravel and large organic matter were removed through a 2 mm sieve, an absolute dry weight at 105°C was gained for chemical analysis.

The micro-kjeldahl method was adopted for the measurement of total nitrogen. Total organic matter was estimated by ignition loss during 24 h at 400°C.

Measurement of dark respiration of rhizome was carried out by Koito System (MASUZAWA, 1987). The assimilation chamber was connected to an open-flow infrared gas analyzer (Fuji Denki ZAP). Samples of rhizome for respiration measurements were selected so as to be 0.5 cm in diameter and 10 cm in length.

3. Results and Discussion

3.1. Vegetation

The timberline of the study site is composed of four deciduous trees, *Alnus maximowiczii*, *Betula ermanii*, *Salix reinii* and *Larix kaempferi* (MASUZAWA, 1985; SAKIO and MASUZAWA, 1988). In the sequence of vertical vegetational zones, there is no belt of dwarf pine (*Pinus pumila*) which is found in many typical high mountains in Japan (HAYATA, 1911, 1929; TOHYAMA, 1968). Instead of a *Pinus pumila* community, *Larix kaempferi* climbs up to the timberline. Alpine meadow above the timberline is thinly covered with some herbaceous perennials: *Polygonum weyrichii*, *Artemisia pedunculosa*,

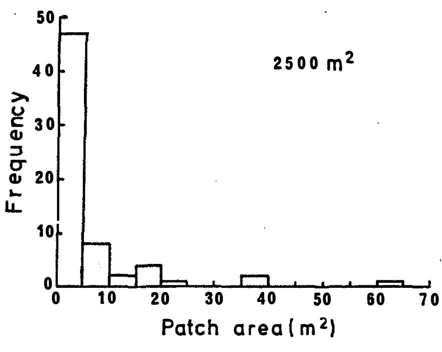

Fig. 1. Frequency distribution of patch area of P. cuspidatum *in the sample plot (50 m×50 m) at the end of the growing season of 1987.*

Carex doenitzii, Polygonum cuspidatum, Campanula punctata var. *hondoensis* and *Arabis serrata*. Patches of *P. weyrichii* and *P. cuspidatum* are dominant near the timberline, and *A. serrata* is found at the highest elevation.

P. cuspidatum forms a patch by vegetative propagation and 65 patches were present within the investigated quadrat. Among these, patches having an area of 0–5 m^2 accounted for about 72% of the total, and a single large patch attaining to 65 m^2 was also present (Fig. 1). The total patch area was 370 m^2 and the coverage was about 15%.

3.2. *Structure*

For the three patches in the investigated quadrat, the number and density of shoots, the biomass above the ground, and the average dry weight per shoot are shown in Table 1. Since a high correlation between D^2H and dry weight holds with respect to the shoots for all sizes of patch, the biomass of each patch was estimated from this correlation. D^2H was calculated by the square of diameter (D) at shoot base and height (H) of shoot. The resulting estimates of the biomass above the ground for the large, medium and small patches were about 3400 g, 970 g, and 120 g, respectively. The number of shoots was 164 in the small, 708 in the medium, and 1727 in the large patch. On the other hand, the shoot density and average biomass showed the highest values of 126.4 and 127.7 g per square meter in the medium patch, respectively. The value of the dry weight per shoot increased from the small to the large patch, and its value for the large patch was 2.0 g per shoot.

Variation in shoot height in each patch was measured along the belt transect (Fig. 2). Shoot height in the small patch changed from low in the periphery to high in the central part, and in the medium patch it showed a plateau-type pattern. In the large patch, the average shoot height was 40 cm at the periphery and about 10 cm in the central part. In the central part, invasive *P. weyrichii* was competing with other invasive species, especially *Saussurea triptera*. *P. cuspidatum*, gradually expanded new shoots radialy from the central part to the periphery.

When a *P. cuspidatum* patch attains a large size, the biomass in the central part decreases and other species invade there. All of the individuals invading into the large patch were perennial and represented by *Saussurea triptera*, *A. serrata* and *A. pedunculosa* with the exception of a small number of other species.

Table 1. Structure of each patch of P. cuspidatum, *S: Small, M: Medium, L: Large patch.*

	Polygonum cuspidatum		
	Small	Medium	Large
Area (m^2)	1.44	5.6	31
Number of shoot per patch	164	708	1727
Density of shoot (no/m^2)	113.9	126.4	55.7
Biomass of above ground per patch (g)	123.1	967.3	3445.5
Biomass (g/m^2)	85.5	127.7	111.6
Dry weight per shoot (g)	0.75	1.37	2.00

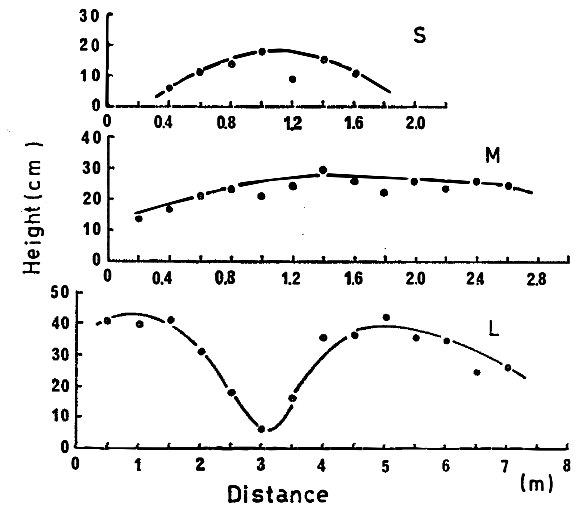

Fig. 2. *Belt transect data of the height in small medium and large patches. Belt was set from the upper side to the lower side of each patch, on an easy slope. S: Small, M: Medium, L: Large patch.*

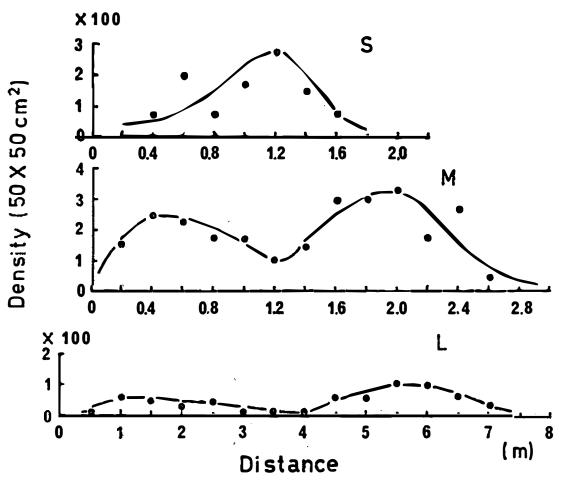

Fig. 3. *Belt transect data of the density in small, medium and large patches. Density is shown by the number of shoots in 2500 cm² (50 cm × 50 cm). S: Small, M: Medium, L: Large patch.*

Figure 3 shows variation in the shoot density ($50 \times 50\,cm^2$) for each patch. The density of the small patch changed from low in the periphery to high in the central part. In the medium patch, the density in the central part decreased to about 100 per $50 \times 50\,cm^2$, though the height of the shoots did not change. Thus, in spite of unchanged height in the central part, a diminution of density has begun in the medium patch. In the large patch, the variation in density showed a similar tendency. The average density decreased in the large patch and the value changed from about 100 at points of 5–6 m to about 5 in the central part. In the central part, most shoots of *P. cuspidatum* have been replaced by those of invading species.

In the medium patch, the nitrogen content and ignition loss of soil were compared between peripheral and central parts at various depths (Table 2). The nitrogen content in the central part was higher than in the peripheral part for each depth. The value of the central part showed 0.59‰ at the ground surface (0 cm), 0.13‰ at a depth of 15 cm and 0.18‰ at 30 cm. These values were approximately three times those of the peripheral part at each depth. The soil nutrient levels were found to change from low to high in accordance with patch growth. Soil condition is older in the central part

Table 2. Nitrogen concentration and ignition loss in the soil on central and peripheral parts of medium patch at 0 cm, 15 cm, 30 cm depth from the ground surface.

Depth (cm)	Central part		Peripheral part	
	Nitrogen (‰)	Ignition loss (%)	Nitrogen (‰)	Ignition loss (%)
0	0.59	2.98	0.19	0.98
15	0.13	1.03	0.05	0.46
30	0.18	1.04	0.05	0.68

than in the peripheral part from the viewpoint of patch growth. The difference in ignition loss at the ground surface showed a similar tendency to that of the nitrogen content, though the magnitude of change at the 15 cm and 30 cm depths was smaller. In other words, eutrophication by litter in the central part was more advanced than in the peripheral part.

The respiration rate of the rhizomes in the central part of a *P. cuspidatum* patch was measured to find the relationship between the rhizome activity and the low biomass of its central part. Respiration rates of about 1.3 mg CO_2 in the peripheral part, and of about 0.5 mg CO_2 $g^{-1}h^{-1}$ in the central part were obtained in August on the large patch. There was a similar tendency observed in September for the respiration of the rhizome in the peripheral part to be higher than that in the central part. The low biomass of the central part was related to low respiration rate. The low biomass of rhizome may be caused by the competition with the invasive species.

Patch growth of harbaceous perennials has been studied with regard to *Phragmites communis* (BUTTERY and LAMBERT, 1965; HASLAM, 1969, 1970, 1971), *Phragmites australis* (KUDO and ITO, 1988) and *Pteridium aquilinum* (WATT, 1940, 1974). However, there have been no ecophysiological studies on patch structure according to patch size, especially on the activity of rhizome and soil development in the patch.

In the present study it was found that the activity of the central part is lower than that of periphery. Although the cause remains to be clarified, this is thought to result from the crowding and aging of the underground organ of the central part, which may cause the central biomass above the ground to wither, and as a result, a doughnut phenomenon is brought about.

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