Natural and semi-natural grasslands in Japan with special reference to *Sasa* dwarf bamboo grasslands

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Summary

Dwarf bamboo grasslands of genus *Sasa* are common in Japan. *Sasa* bamboos often form almost pure grasslands, which indicates that they have large competitive exclusion ability on association plant species. The ability is ascribable to a mechanism to keep uniformly and constantly large amount of leaves that deprive associate plants of light to grow. The mechanism is a strong feedback regulation of leaf production by culms and branches. When *Sasa* bamboos occur under forests,.they deprive over-growing trees of soil water to reduce growth of them. Thus *Sasa* bamboos seriously affect growth of associate plants both out and within forests. Because of their commonness and dominance in vegetation of Japan, we cannot ignore the effects of *Sasa* bamboos when we consider ecosystems in Japan.

Key words*: competition, regulation of leaf production, light, water content of soil*

Introduction: Grasslands in Japan

Forests cover 75 % of Japanese land by virtue of abundant annual precipitation ranging from 900 through 3500 mm; Japan is one of the rainiest countries in the temperate zone. Since Japan has a domain elongating from north to south and from the sea level to 3776 m a. s.l., forest types change from warm temperate evergreen forests in southern region through cool temperate deciduous ones in central region to semi-boreal conifer ones in northern region (Numata & Iwase 1975) (Fig. 1). The same change occurs from the coast to high mountains

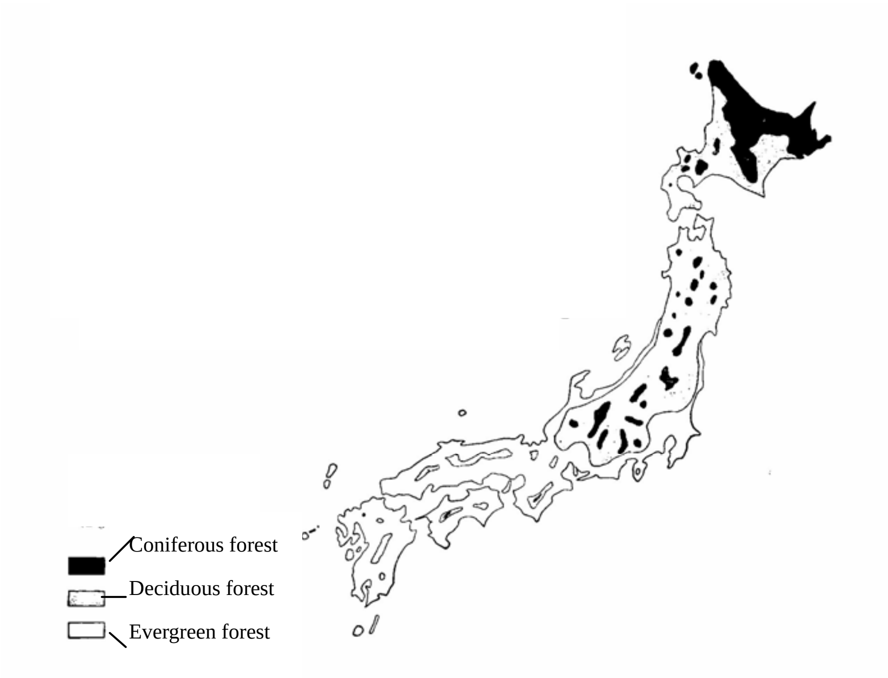

Fig. 1 Vegetation map of Japan.

in central Japan. The evergreen forests stretches their distribution to southern slope of Himalaya, and the deciduous forests that are often dominated by beech resemble to those in Europe and East coast of U. S. A.

Japan is surely a forest country, but it also has a wide area of natural and semi-natural grasslands. Ancient Japanese celebrated their country as ‘the country that is blessed with vast wet grasslands’, because they could raise rice in wetlands. Therefore most of wetlands had been converted into paddy fields. Large wetlands now remain only in Hokkaido. Kushiro moor is one of those remnant wetlands, having an area of 27,000 ha. Slash-and-burn agriculture extended semi-natural grasslands that had been used by farmers to collect thatch and fodder, and to raise cattle. Geographical variations of semi-natural grasslands are shown in Fig. 2 (Numata 1969). Near the tops of high mountains, meadows dominated by forbs

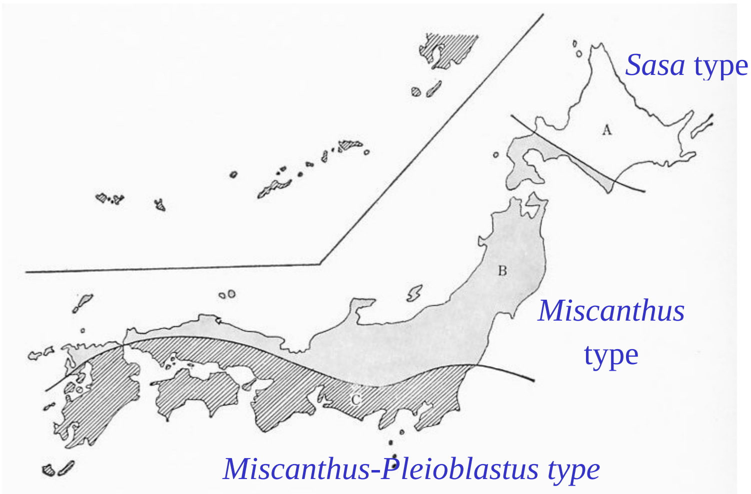

Fig. 2 Distribution of semi-natural grassland types in Japan.

develop. Dwarf bamboo grasslands are another common type of Japanese grasslands, and are unique to the humid temperate zone of Asia, Africa and South America. Dwarf bamboo grasslands are often almost pure community dominated by one species of dwarf bamboo. Genus *Sasa* is a common dwarf bamboo in Japan and can grow and dominate under forest canopy as well.

Sasa bamboo grasslands

Competitive exclusion ability of *Sasa* bamboos seems to be large because of smaller number of associate plants in their grasslands (Fig.3). However the ability varies as *Sasa* bamboos

Fig. 3 Vertical section of a Sasa tsuboiana grassland. Few plants grow under the canopy of S. tsuboiana.

vary their height or cover. To detect changes in the competitive exclusion ability of a *Sasa* bamboo (*Sasa tsuboiana*), I compared the number and total cover of associate species among habitats varying in height and cover of *S. tsuboiana* on Mt. Horai, 24 km of northeast to Kyoto. *S. tsuboiana* was tall and dense on the lower slope, but decreased in height towards the upper slope. It grew sparse as well as short at a few places on the ridge. Woody plants also decreased in height and cover towards the ridge (Fig. 4). The number of species per unit area was small and no herbaceous plants covered more than 1 % in the tall and dense *S. tsuboiana* community on the lower slope (Fig. 5). However, once S. tsuboiana decreased in abundance, herbaceous species appeared with large number of species and large cover of respective

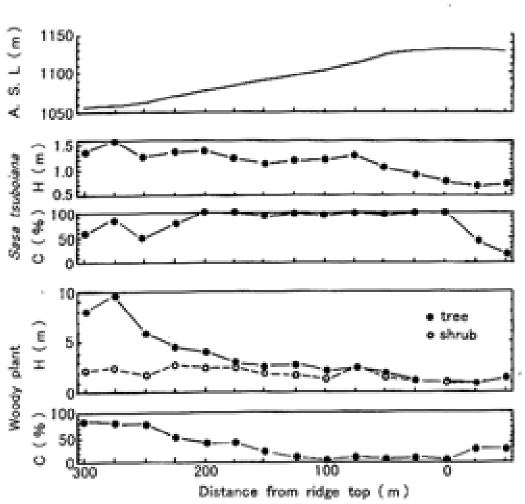

Fig. 4. Change in the height (H) and cover (C) of S. tsuboiana and woody plants along a belt down from a ridge.

species in comparison with the tall and dense *S. tsuboiana* community (Fig. 5). Disturbance by mowing *S. tsuboiana* grasslands decreased abundance of *S. tsuboiana* and also led to the larger number and greater cover of herbaceous species (Fig. 5). These results show that the

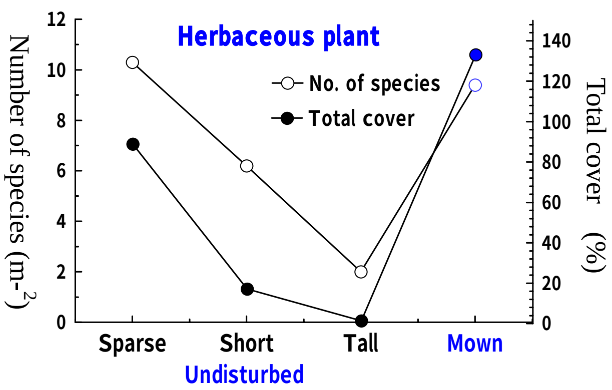

Fig. 5. Number of species per 1 m² and total cover (%) of species in undisturbed grasslands and a disturbed S. tsuboiana grassland.

competitive exclusion ability of *S. tsuboiana* is large in undisturbed suitable habitats, and the ability decreases as *S. tsuboiana* abundance decreases.

To clarify what properties account for the large competitive exclusion ability of *S. tsuboiana*, mechanisms of keeping leaf standing crop were studied for *S. tsuboiana*. Depriving associate plants of light should be one of crucial factors with which a dominant plant to exclude the associate plants. To deprive associate plants of light, the dominant plant must keep large and constant leaf standing crop. To keep the large and constant leaf standing crop, the dominant plant then must have a strong negative feedback regulation mechanism in leaf production. I thus studied a regulation of leaf standing crop in *S. tsuboiana* through compare leaf production of old branches and culms between those receiving stronger light and those not. Upper 1-year-old branches, which received stronger light on average, produced more leaves than lower branches, which received weaker light on average (Fig. 6). Culms of 1-year and older in thinned plots produced more leaves per culm than those in un-thinned

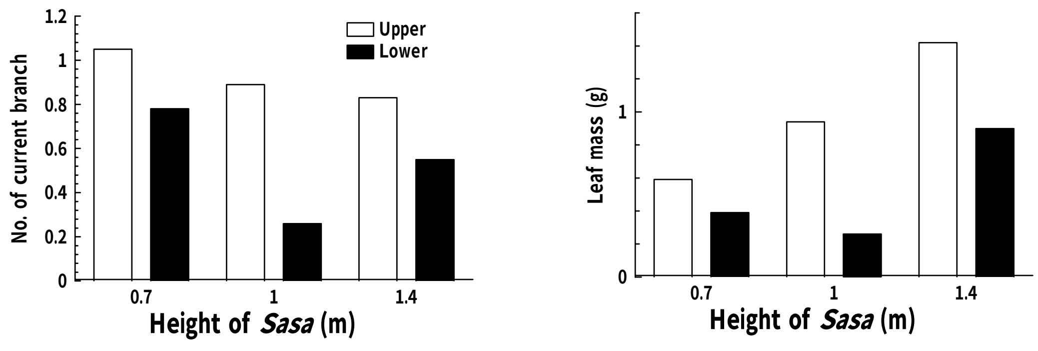

Fig. 6. Comparison between upper and lower 1-year branches in the number of current branches (right) and current leaf mass (left) per 1-year branch.

plots (Fig. 7). These results show that branches produce more leaves per branch than usual, when leaf standing crop falls to lower level than usual and branches receive stronger light. We can conclude that *S. tsuboiana* has a feedback regulation in leaf production and that it can hereby keep a constant leaf standing crop from one year (or place) to another. Standing crop

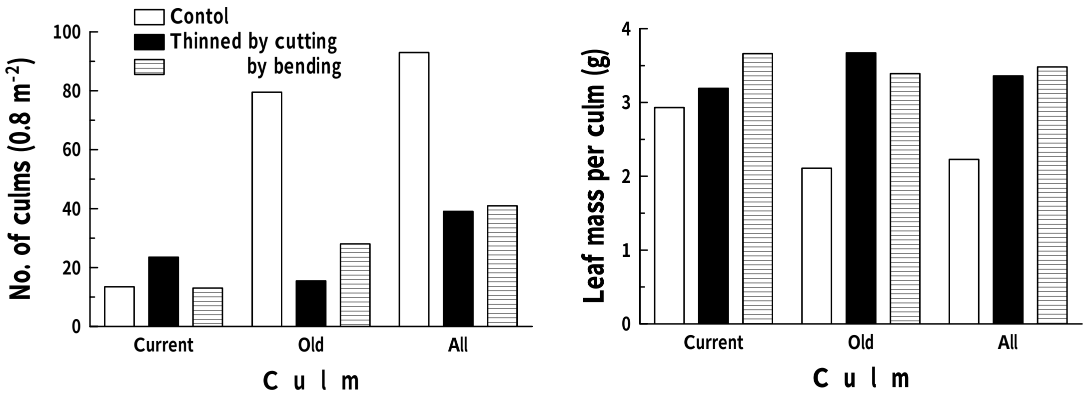

Fig. 7. The number of old culms (right) and current leaf mass per culm (left) in thinned and un-thinned plots.

of current leaves is constantly 280 g/m^2 over a wide range of *S. tsuboiana* grasslands in mid-August regardless of *S. tsuboiana* height where it keeps dense cover (Fig. 8). In contrast, standing crop of current leaves was much smaller in those communities that had more species than the dense *S. tsuboiana* grasslands, such as sparse *S. tsuboiana* grasslands and mown *S. tsuboiana* grasslands; the leaf standing crop was 80-120 g/m^2 for these grasslands. The uniformly constant leaf standing crop of *S. tsuboiana* throughout the undisturbed suitable habitats brings about uniformly weak light conditions under the canopy of *S. tsuboiana*. Associate plants therefore hardly find safe sites to grow under *S. tsuboiana* canopy. The large competitive exclusion ability of *S. tsuboiana* in undisturbed suitable habitats owes to its own large ability of regulation over leaf standing crop.

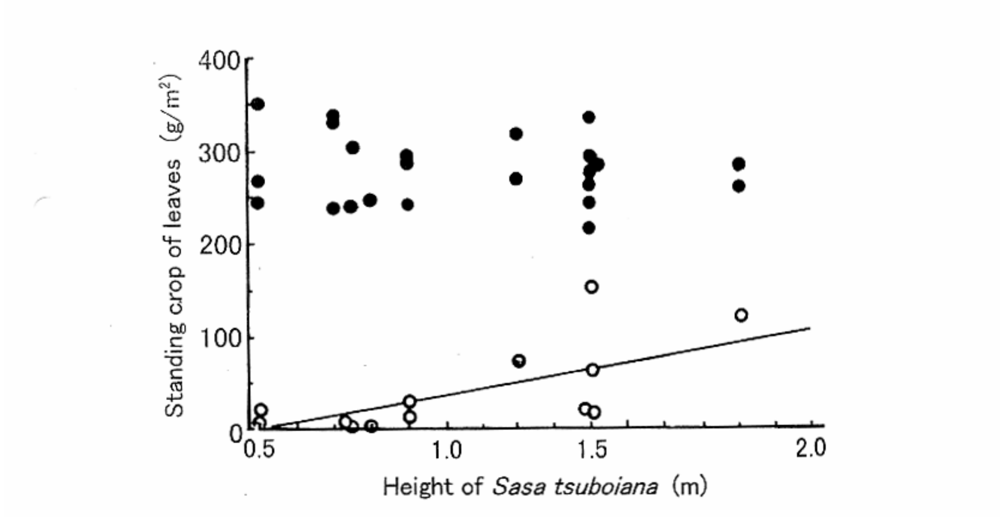

Fig. 8. Constant current leaf amount (solid circle) with height of S. tsuboiana grasslands. Open circle indicates leaf amount of 1-year leaves.

Sasa bamboos deprive of not only light but also of water that are otherwise available to associate plants. Takahashi et al. (2004, in printing) show that removal of a *Sasa* bamboo (*S. kurilensis*) from forest-floor increased soil water content (Fig. 9) and enhanced growth of trees (*Betula ermanii*) in comparison with those values in untreated plots (Fig. 10). Since

and open circles indicate un-removed and removed plots, respectively.

the trees were taller than the dwarf bamboos, the removing did not improve light, it should be an increasing of water content that accounts for the in enhancement of tree growth in the plots of the Sasa bamboo removal. This result shows that *Sasa* bamboos growing under trees deteriorate growth of trees through competition for soil water with roots.

In conclusion, dwarf bamboos affect growth of associate plants in wide area of Japan by depriving light and water. Without taking into consideration of the effects of *Sasa* bamboos, we cannot understand many of ecosystems in Japan.

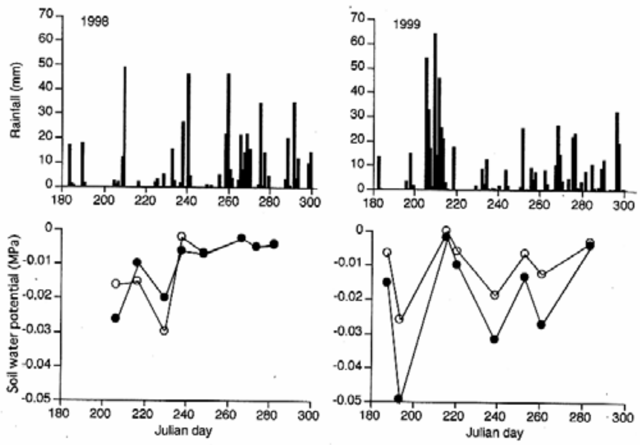

Fig. 9. Water potential of soil before (right) and after removal (left) of Sasa bamboos. Solid

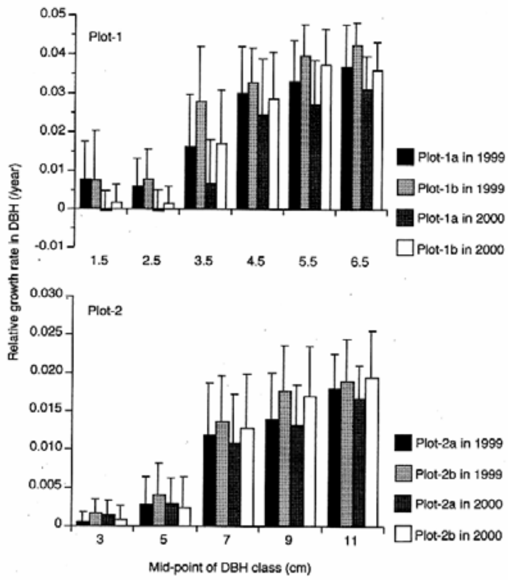

Fig. 10. Relative growth rate of trees (a species of birch). Sasa bamboos were removed on the end of 1998.

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