Botanical Studies (2006) 47: 185-190.

ECOLOGY

Effects of periodic cutting on the structure of the *Mikania micrantha* community

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(Received August 12, 2004; Accepted December 5, 2005)

ABSTRACT. *Mikania micrantha* H.B.K., an aggressive exotic climber, has caused significant damage to many ecosystems in the Guangdong province in recent years. To study the plant community dynamics and develop methods for control of this weed, we investigated in the effects of periodic-cutting on *M. micrantha* in Dongguan, Guangdong province, in south China. We harvested the aboveground biomass of our cut treatment and control plots of *M. micrantha* once every two months for a year. Results show that periodic-cutting reduced the competitiveness of *M. micrantha,* changed the composition of its community, and promoted growth of native and other non-native species, especially those of Compositae species. Considering costs of time and labor, resilience of *M. micrantha* is too high strong that too high to control completely by periodic-cutting once every two months, but periodic-cutting is an effective, safe, and easy method to put into practice for forests and plantation crops.

Keywords: Community structure; Exotic species; Invasion; *Mikania micrantha*; Periodic-cutting; Species diversity.

INTRODUCTION

Invasion of exotic species into native plant communities is pervasive and widespread, and it has substantial negative effects on native community structure and function (Heywood, 1989; Macdonald et al., 1991; Timmins and Williams, 1991; D'Antonio and Vitousek, 1992; Berger, 1993; Hobbs and Humphries, 1994; Cronk and Fuller, 1995; Higgins et al., 1999). We have not found an effective method that can be used to control all harmful alien plant species, because of differences in biological and ecological traits among these species. To control them, mechanical, chemical, and biological methods, or some combinations of these, are commonly used (Berger, 1993; Maffei and Marin, 1999; Peng and Xiang, 1999; Li and Xie, 2002).

Mikania micrantha H.B.K. (Compositae), a climbing perennial weed that originated from South and Central America (Hills, 1999; Maffei and Marin, 1999). Since its introduction to China in 1919, *M. micrantha* has spread extensively. It has been called a plant-killer since it causes native species to disappear (Zhang et al., 2004). The species is destructive to forests and plantation crops, such as tea, teak, rubber, and oil palm, and it causes economic losses and decline in native biodiversity. Since the 1960s, various efforts to control *M. micrantha* have been reported, such as mechanical, biological, and chemical control (Bogidarmanti, 1989). Herbicides are very effective in controlling this weed (Zhang et al., 2004), but they cause serious environmental problems. Removing *M. micrantha* manually is the best way to control this weed since herbicides and mechanical removal have undesirable effects on the community. Cutting *M. micrantha* vines near the ground once a month can eliminate 90% of them at the individual level (Kuo et al., 2002). In the growing season for *M. micrantha* in 2000, the Shenzhen government hired thousands of citizens to hand pull the weed. This was quite effective, and many dying trees damaged by *M. micrantha* recovered (Feng et al., 2002). To control *M. micrantha* by cutting on the community of *M. micrantha* in natural environment in South China, we need to understand how *M. micrantha* community is affected by this manipulation. Therefore, we initiated this project to study the effects of cutting *M. micrantha* on plant community dynamics during one growing season under a low subtropical climate.

MATERIALS AND METHODS

Study site

We set up experiments in an abandoned litchi garden in a hilly area between main road Dongguan and Dongguan Avenue, west of Dongguan city center (113°31'~114°15'E, 22°39'~23°09'N). The climate is typical subtropical with

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marine monsoon. It is warm and humid with mild winters, long hot and humid summers, and lots of sunshine. The rainy season is from April to September. Soil samples from the 0-10 cm mineral horizon were collected from our experimental plots at the beginning in June 2002. In recent years, human activities have badly destroyed the natural vegetation in this area, which has resulted in favorable conditions for alien species invasion. Our study site was dominated by *M. micrantha*, with coverage of over 80%. The other dominant plant species in the *M. micrantha* community were the non-native *Ageratum conyzoides* and *Bidens pilosa* and the native *Urena lobata*.

Experimental design

To examine the influence of periodic cutting on *M. micrantha*, we set up 10 1 m × 1 m plots. Once every two months from June of 2002 to June of 2003, we harvested the aboveground plant biomass by clipping from each of these plots and from the other 10 uncut control plots each time. That is, there were 10 cutting plots and 70 control ones. Then, all plant material was sorted by species as it was harvested. Biomass was dried at 80°C for 48 h and weighed to obtain biomass.

Measure of diversity

To assess the species diversity of the different control treatments, we calculated the effective species richness ($e^{H'}$) (Dukes, 2002), where,

$$H' = -\sum p_i \ln p_i$$

and p_i is the biomass proportion of species i to the total biomass in a plot at a harvest. Effective species richness measures the number of equally abundant species necessary to obtain a given *H'*.

Statistical analyses

All tests were carried out at a $P<0.05$ significance level using SPSS (version 12.0). All variables were analyzed by a 2-way ANOVA with harvest time and cutting treatment as main factors. When the interaction was significant, the treatment effects were tested by a t-test for each harvest time. As harvest time was not our main interest, we did not use multiple range tests to compare all the means of the interaction. Since the interaction was significant for all variables tested, we will not present its results individually.

RESULTS

Influence of periodic cutting on biomass in *M. micrantha* community

Influence of cutting on aboveground community biomass. Periodic cutting resulted in significantly decreases in aboveground biomass of *M. micrantha* community on all of our harvest days (Figure 1). In June 2003, the mean total *M. micrantha* community biomass in plots with periodic cutting was 46.0% less than of the uncut plots (215.2±30.9 g/m^2 vs. 398.2±51.6 g/m^2). In the control, aboveground biomass of the *M. micrantha* community varied with time of year, with the highest in June, which was about 2.8 times that of the lowest in February. During the growing season from June to October 2002 and from April to June 2003, the biomass of cut plots was only about half of that of uncut plots (54.0% in August, 52.3% in October 2002, and 54.0% in June 2003). It is also clear that the *M. micrantha* community has great ability to recover from cutting (Figure 1). In the 2002 growing season, the ratio of the community aboveground biomass between June and August was 49.0%, 64.3% between August and October. In the non-growing season, the ratio was 28.0% between October and December 2002, and 21.7% between December and February 2003.

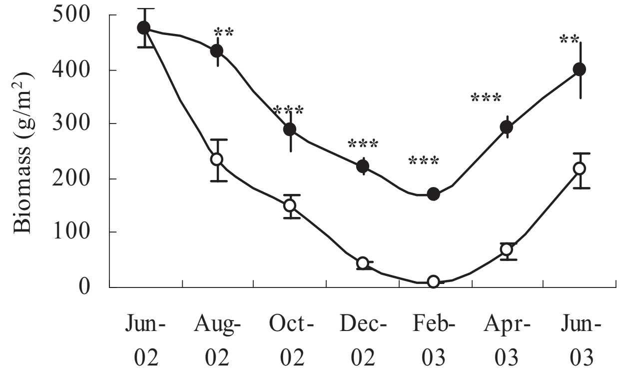

Figure 1. Total community aboveground biomass (mean±SE, n=10) in cutting (○) and control (●) plots. The asterisks indicate significant difference between treatments (*$P<0.05$, ** $P<0.01$, *** $P<0.001$) at individual harvest days.

Influence of periodic cutting on biomass of M. micrantha. Periodic cutting significantly reduced the biomass of *M. micrantha* on all the harvest days (Figure 2a). In June 2003, the mean *M. micrantha* biomass in the infected plots was 75.3% less than of the control plots (86.0±24.2 g/m^2 vs. 348.1±51.6 g/m^2). The mean aboveground biomass of *M. micrantha* per plot varies with time (Figure 2a). In control plots, the maximum biomass was in August 2002 and the minimum in February 2003 (Figure 2a). Community biomass in the control was dominated by *M. micrantha*, and the proportion of *M. micrantha* biomass to the total was about 90%, except for June 2002 and April 2003 when it was about 60% (Figure 2b). In cutting plots, *M. micrantha* biomass proportion decreased almost linearly from August 2002 to February 2003 (Figure 2b). From February to June 2003, the proportion of *M. micrantha* biomass increased almost linearly (Figure 2b), and it was less than 40%. It is clear that cutting decreased the proportion of *M. micrantha* biomass in the community, except from June to August 2002 (ANOVA, F=11.766, P=0.006) (Figure 2b). The proportion of *M. micrantha* biomass of the first cutting increased from 61.6% to 86.8% though biomass of community and of *M. micrantha* decreased from June to August 2002 (biomass of community from 476.3±37.2 g/m^2 to 233.3±38.5 g/m^2; biomass of *M. micrantha* from

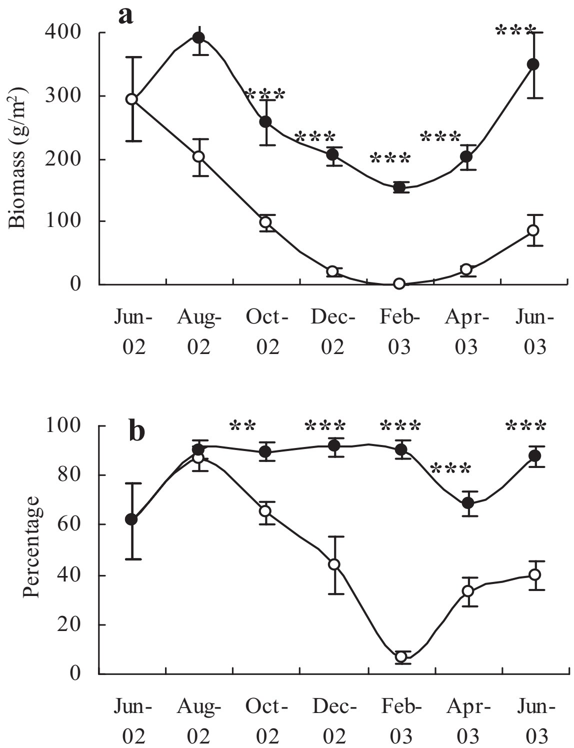

Figure 2. Mean plot biomass (mean±SE, n=10). (a) and relative biomass (mean±SE, n=10); (b) of *M. micrantha* in cutting (○) and control (●) plots. Refer to Figure 1 for the definitions of the asterisks.

293.6±66.9 g/m^2 to 202.5±29.5 g/m^2). This indicates that the ability of *M. micrantha* to recover is high, so the rate of the re-growth is high after the first cutting.

Influence of cutting on biomass of companion species. In control plots, proportions of biomass in both native and non-native species were about 10% during our experiment (Figure 3a, 3b). These species were overgrown by *M. micrantha* (Figure 2b). In the cutting treatment, the biomass proportion of other invasive species increased from 16.9% in June 2002 to 65.9% in April 2003. Biomass proportion of native species was lower than 20%, except in February 2003 (Figure 3b). In February 2003, biomass proportion of native species was >40%.

In our experimental plots, the main Compositae species were *Ageratum conyzoides*, *Bidens pilosa*, and *Conyz abonariensis*. Their biomass proportions were increased by cutting (Figure 3c), and they were much higher than those of the control treatment, except in June and August 2002 (Figure 3c). All three Compositae species are exotics. Their relative biomass increased to 65.0% in April 2003 in the cut plots.

Influence of cutting on litter biomass. Litter biomass of periodically cut plots was stable and negligible, and the amount was much lower than that of control (ANOVA, F=63.886, P<0.001) (Figure 4). Also, litter biomass of control plots fluctuated with time.

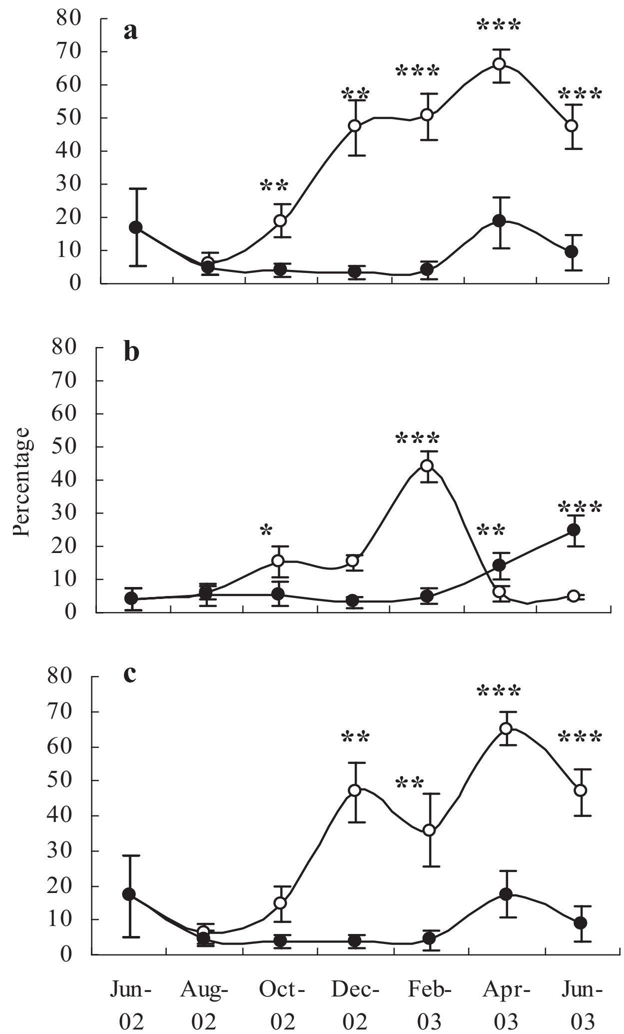

Figure 3. Mean relative biomass (mean±SE, n=10) of companion species in cutting plots (○) and control plots (●). a, nonnative species; b, native species; c, Compositae species. Refer to Figure 1 for the definitions of the asterisks.

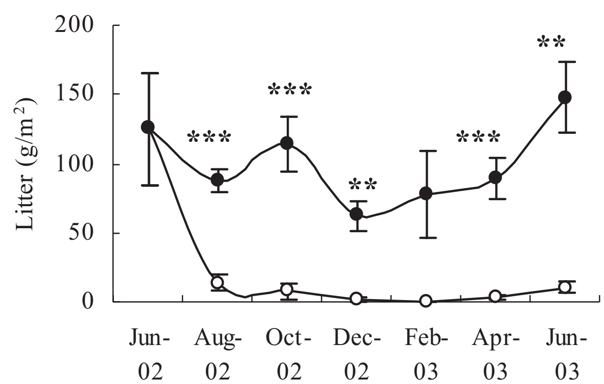

Figure 4. Mean amount of litter (mean±SE, n=10) in cutting plots (○) and control plots (●). Refer to Figure 1 for the definitions of the asterisks.

Influence of periodic cutting on structure of the *M. micrantha* community

Influence on number of species. Periodic cutting resulted in increasing in number of species, according calculating of the total number of species in 10×2 plots, and increases in native species were more pronounced than in exotic species (Figure 5). In control plots, species were in both fluctuation and stable states. That is, number of species in the community was the same on given dates between years, but it changed with the season. This was true for both native and non-native species; native species were in the same dynamic state as all the species. At the end of our experiment, there were 6 native species while 3 exotic ones.

Compared to control, periodic cutting promoted invasion of non-native species. In cut plots number of species increased from 7 to 23, as about 3 times the numbering as the control plots, which was 9. At the end of our experiment, there were totaling 16 native and 7 exotic species.

Influence on species diversity. Periodic cutting resulted in higher species diversity and in greater variation in (Figure 6). In control treatment, the diversity index changed very little from June 2002 of 1.9 to April 2003 and then increased to 2.7 in June 2003. In periodic cutting, diversity was reached a maximum of 10.0 in February 2003, and then it decreased to 4.1 in June 2003.

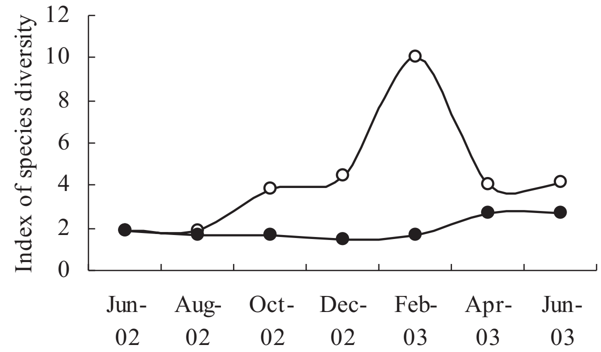

Figure 6. Species diversity in cutting (○) and control plots (●).

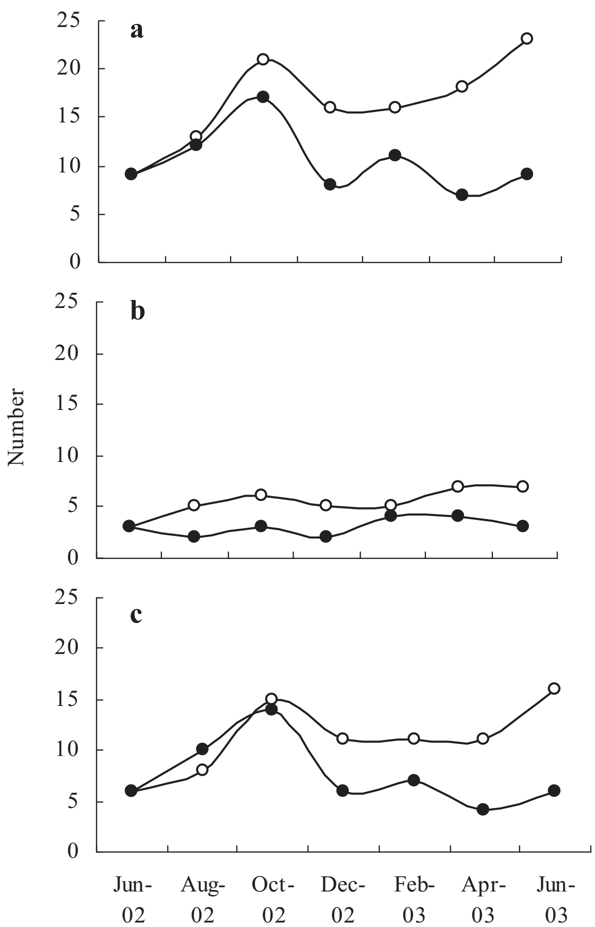

Figure 5. Number of species in cutting (○) and control plots (●). a, all the companion species; b, native species; c, other non-native species.

DISCUSSION

Our results indicate that periodic cutting has considerable influence on species richness of the *M. micrantha* community. Cutting reduced the biomass of *M. micrantha* and increased species diversity of the community. These results supported the intermediate disturbance hypothesis (Connell, 1978). Connell proposed that species diversity was maximized under intermediate levels of disturbance. Thus, bimonthly cutting was likely intermediate disturbance for the *M. micrantha* community. The process of regrowth showed that dominance of *M. micrantha* was reduced by periodic cutting, which created opportunities for other species to establish in the community. This is why the number of species, the index of species diversity, and biomass ratio of other species increased more in the cutting treatment than it did in the control.

Disturbance by frequent cutting of the *M. micrantha* community caused invasion by other non-native and of native species. These results are in accord with the competitive mechanisms responsible for invader superiority (Petren et al., 1993). That is, disturbance enhanced community invasibility. Elton (1958) suggested that low community diversity caused greater invasion. Our result agrees with this concept, though some opinions differ from those of Elton (Robinson et al., 1995; Palmer and Maurer, 1997; Higgins et al., 1999). After invasion by *M. micrantha*, the community accorded with the negative theory of community diversity to invasibility. In a year of bimonthly cutting, number of native and other non-native species increased as did their biomass proportion.

Periodic cutting increased the relative biomass of other Compositae species. With decrease of the *M. micrantha* population, biomass percentages *Ageratum conyzoides*, *Bidens pilosa* and *Conyz abonariensis*, increased continuously. This result agrees that of with Bao et al. (2003), who also found that Compositae species increased under different mowing regime for 19 years in the steppe dominated by *Leymus chinensis*.

Periodic cutting effectively controlled *M. micrantha* and promoted recovery of native species. However, *M. micrantha* has a great ability to recover following cutting. The proportion of *M. micrantha* biomass increased after the first cut. Its relative biomass in the growing season was still >40% during the bimonthly cuttings, and it was increasing after senescence in February. It seems that cutting at intervals of less than two months would be more effective than the 2-month cutting interval. Although cost of periodic cutting is high, herbicide and mechanical removal can have undesirable affects on non-target species and on the environment. Thus, for forests and plantation crops, cutting is an effective, safe, and easy method to put into practice for controlling *M. micrantha*.

Acknowledgements. We thank Dr. Wang Zhangming for advice on data analysis and English language revision, Fu Qiang, Deng Xiong, Yang Qihe, Shen Hao and Hong Lan for their reliable assistance with measurements and help in setting up the experiment, and Cai Chuxiong and Ye Wanhe for help with harvests. This work was supported by the State Key Basic Research and Development Plan of China (No. G2000046803), Guangdong provincial Natural Science Foundation of China (No. 021536 and No. 05200701) and the National Natural Science Foundation of China (No. 30530160).

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連續刈割對外來入侵種薇甘菊群落結構的影響

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本項研究以刈割入侵植物薇甘菊群落恢復的動態監測資料為依據，用生物量衡量群落的功能多樣性，從群落植物種類組成、生物量、物種多樣性等方面探討薇甘菊群落的基本特徵，為薇甘菊的防控提供科學的參考依據，並希望有助於外來入侵種群落水平的研究。根據全年的定期監測資料分析可知，連續的刈割導致薇甘菊群落物種組成和功能均有較大改變；薇甘菊雖具有極強的恢復力，但刈割還是抑制了薇甘菊種群的競爭勢，促進了其他外來種和本地種的“入侵”，尤其是其他外來菊科植物。由此可見，兩個月一次的刈割雖然耗費較多的人力物力，但對於受害嚴重的森林及農林仍不失為有效安全的控制方法。

關鍵詞：群落結構；外來種；入侵；薇甘菊；連續刈割；物種多樣性。