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Holoparasitic *Cuscuta campestris* suppresses invasive *Mikania micrantha* and contributes to native community recovery

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ABSTRACT

Traditional biocontrol uses introduced non-native agents to control alien invasive species. Recently, using species of the invaded regions to control invaders has been proposed as a potential alternative to traditional biocontrol. To explore the effects of the obligate parasite *Cuscuta campestris* in the invaded regions on controlling the alien invasive weed *Mikania micrantha* and on recovering the heavily invaded communities in the coastal Guangdong Province in South China, we conducted a field survey in four sites on the Neilingding Island where *Cuscuta* has been artificially introduced to the *Mikania*-invaded communities for one to 4 years, and also three sites in Shenzhen, Dongguan and Haifeng where the *Mikania*-invaded communities have been naturally parasitized by *Cuscuta* for at least 5 years. *Cuscuta* effectively suppressed the growth and invasiveness of *Mikania*, leading to its decline. The restraint on *Mikania* by *Cuscuta* increased richness and diversity of native plants, contributing to native community recovery. Moreover, *Cuscuta* declined with decreasing *Mikania*, and its parasitism rate on *Mikania* was much higher than that on the native species, suggesting little non-target effects. The effects of *Cuscuta* varied little among sites of Shenzhen, Dongguan and Haifeng, but increased greatly with time of introduction on the Neilingding Island. Our results suggest that *Cuscuta* is an effective agent for controlling *Mikania*, and that enemies of the invaded regions may be a promising alternative to traditional biocontrol.

1. Introduction

Plant invasions have received worldwide attention. They occur on every continent (Henderson et al., 2006), especially in riparian and disturbed habitats (Drayton and Primack, 1996; Lake and Leishman, 2004; Holway, 2005), and have caused great economic costs and environmental problems (Alpert et al., 2000; Richardson et al., 2000).

Methods to control invasive plants have been investigated extensively, including mechanical (Snow and Marrs, 1997; Britton et al., 2000; Timmins, 2004), chemical (using herbicides; Marrs, 1985; Paynter and Flanagan, 2004) and traditional biological control (Mack et al., 2000; Messing and Wright, 2006). However, mechanical measures may potentially accelerate invasions, and chemical measures can be detrimental to non-target species and ecosystem health in the long run (Marrs and Frost, 1997; Milligan et al., 2003; Mason and French, 2007). Traditional biocontrol that introduces natural enemies of the invaders from their native ranges to control the target invaders (DeBach, 1974) is somehow an ecologically benign pest management measure in wild lands and nature reserves (Lesica and Hanna, 2004; Messing and Wright, 2006).

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However, the species- and habitat-specificities of natural enemies are great challenges to traditional biocontrol (Simberloff and Stiling, 1996; Torchin and Mitchell, 2004). Some introduced predators, parasitoids and herbivores attack non-target, native species and even become invaders themselves (Simberloff et al., 2005). They may also cause competition, displacement and other ecological interactions (Messing and Wright, 2006). Therefore, the focus on controlling invaders has turned towards ecologically-based, longer-term alternative solutions (Marrs and Britton, 2000; Hansen, 2007; Richardson et al., 2007).

Interactions between species of the invaded regions (i.e., native species or naturalized exotic species) and alien invasive species can also limit invasions (Alpert et al., 2000; Corbin and D'Antonio, 2004). Species (predators, parasitoids and herbivores) of the invaded regions match local phenology and have co-evolved with many native species (Callaway, 1995; Simmons, 2005). Therefore, using species of the invaded regions to control invaders reduces the risk of unpredicted and undesired negative effects on non-target species (Sakai et al., 2001; Callaway and Ridenour, 2004) and may be an alternative approach to the traditional biocontrol (Guo, 2006; Parker et al., 2003, 2006).

There are increasing interests in the control of invaders by species of the invaded regions (Sheldon and Creed, 1995, 2003). Julien and Griffiths (1998) listed 20 native pathogens and 40 native insects used worldwide as potential biocontrol agents of alien plants. Parker et al. (2006) compared 63 manipulative field studies involved 100 exotic plants and concluded that some native herbivores suppressed exotic plants. In Europe, the indigenous shield beetle (*Cassida rubiginosa*) may be used to control the creeping thistle *Cirsium arvense* (Bacher and Schwab, 2000). In North America, a native weevil (*Euhrychiopsis lecontei*) was reported to greatly suppress water milfoil *Myriophyllum spicatum* (Creed and Sheldon, 1995; Newman, 2004). Another example is an indigenous parasitoid wasp (*Chouioia cunea*) used against the alien invasive fall webworm (*Hyphantria cunea*) in China (Yang et al., 2006).

In South China, the alien invasive herb *Mikania micrantha* (hereafter the genus name only) has invaded a broad range of natural and agricultural lands (Li et al., 2000; Zhang et al., 2004), and caused tremendous economic and environmental problems (Wang et al., 2004; Zhang et al., 2004). Mechanical (Swary and Ramakrishnan, 1987), chemical (Ipor and Price, 1994) and traditional biocontrol approaches can not effectively alleviate the damage caused by *Mikania* (Wang et al., 2004). Recently, the obligate parasite *Cuscuta campestris* (hereafter the genus name only) of the invaded regions was observed to parasitize on *Mikania* in the field, and proposed as a potential agent to control *Mikania* (Wang et al., 2004). Although *Cuscuta* was found to be able to greatly limit the growth and invasiveness of *Mikania* in garden or greenhouse conditions (Zhang et al., 2004; Shen et al., 2005), the controlling effects of *Cuscuta* on *Mikania* have not been fully tested in the field.

To gain a better understanding of the effects of *Cuscuta* on the control of *Mikania* and the recovery of the invaded communities in the coastal Guangdong Province in South China, we conducted a field survey in four sites on the Neilingding Island where *Cuscuta* has been artificially introduced to the *Mikania*-invaded communities for 1–4 years, and also in three sites in Shenzhen, Dongguan and Haifeng where the *Mikania*-invaded communities were found to have been naturally parasitized by *Cuscuta* for at least 5 years. Specifically, we address the following questions: (1) Does *Cuscuta* effectively restrain the invasiveness of *Mikania* in the field? (2) What are the effects of *Cuscuta* on the invaded native communities? (3) Is there any non-target effect of *Cuscuta*?

2. Materials and methods

2.1. The species

M. micrantha H.B.K. (Compositae), native to Central and South America, is one of the ten worst weeds and the 100 worst invasive alien species in the world (Li et al., 2000; Lowe et al., 2001). It smothers other species nearby (Li et al., 2000), and greatly affects soil microbial communities (Ni et al., 2006; Li et al., 2006). Efficient sexual reproduction and fast clonal growth contribute to its spread and invasiveness (Li et al., 2000). Since its introduction in the early 1980s, *Mikania* has invaded large areas of the coastal Guangdong Province in South China (Wang et al., 2004; Liu et al., 2005).

C. campestris Yuncker (Convolvulaceae) is an obligate parasite and occurs in Fujian and Guangdong Provinces as well as in Xinjiang Uygur Autonomous Region in China (Yuncker, 1932; Wu and Raven, 2001; Wang et al., 2004). It is the most widespread parasitic weed in the world (Nickrent and Musselman, 2004) and occurs in Africa, Asia, Australia, Europe, North America, Pacific Islands and South America (Yuncker, 1932; Wu and Raven, 2001). Although *Cuscuta* has a broad range of hosts and can parasitize different plant species (Pennings and Callaway, 1996), it shows strong host preference (Koch et al., 2004; Wang et al., 2004). Since 2000, *Cuscuta* has been scientifically known to naturally parasitize on *Mikania* in South China (Li et al., 2000; Wang et al., 2004). *Cuscuta* could reduce the growth and even cause the death of *Mikania* (Wang et al., 2004). Although it is regarded as a harmful weed in agriculture areas, *Cuscuta* has no significantly negative effect on native plants in natural areas in South China (Wang et al., 2004).

2.2. Natural occurrence of Cuscuta in Shenzhen, Dongguan and Haifeng

Dongguan, Shenzhen and Haifeng are all located in the coastal regions of Guangdong Province in South China (Table 1). These regions are characterized by the typical subtropical climate with warm, humid winter and long, moist summer. In the early 1980s, *Mikania* started to invade these regions, especially the agricultural areas and disturbed lands (Li et al., 2000). The invasion of *Mikania* commonly turned the native community into almost a *Mikania* monoculture, and eliminated many native plants (Wang et al., 2004). In 2000 and 2001, *Cuscuta* was observed to naturally parasitize on 11 *Mikania*-invaded communities in five cities of Guangdong Prov-