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Original article

Role of intraspecific trait plasticity in *Mikania micrantha* Kunth growth and impact of its abundance on community composition

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ABSTRACT

Intraspecific trait variability, which plays an important role in community assembly, was studied in an invasive plant *Mikania micrantha* along with its impact on community composition. The abundance of *M. micrantha* and community composition were recorded in a quadrat-based study conducted on a spatial (littoral, terrestrial, and an intermediate habitat) and temporal (summer, monsoon, and winter) scale. Soil parameters were analyzed and some fitness-related traits of *M. micrantha* were estimated. Season and habitat had significant effects on *M. micrantha* abundance. Seasonal plasticity was evident in leaf-level traits. High laminar nitrogen and leaf dry matter content during the monsoons and a larger leaf area with high chlorophyll content during summer and winter months were responsible for maintenance of its yearlong growth. Multivariate regression analysis revealed that, after adjusting for season and habitat, none of the traits exhibited significant effect on *M. micrantha* abundance. Abundance of *M. micrantha* appeared to be the only factor responsible for decline in associated species richness. Continuous monitoring of the established population and early detection of new infestations of *M. micrantha* are recommended to keep a check on excessive growths to prevent it from becoming problematic in subtropical regions of the world.

Introduction

Mikania micrantha Kunth (Asteraceae), commonly known as "mile-a-minute" weed, is an herbaceous terrestrial creeper with a pantropical distribution (Day 2012). From its vast native biogeographic range (South and Central American countries along with the Caribbean islands), the plant has now spread to Oceania (e.g. Australia, American Samoa, Papua New Guinea, Fiji) and most of the Asian countries (e.g. India, Indonesia, Malaysia, China), and is considered as one of the top 10 worst weeds of the world (Holm et al 1977). *M. micrantha* is one of the major invasive plants in natural forests, plantations including tea and agricultural systems in several Indian states (Puzari et al 2010; Sankaran et al 2008), and is also a cause of serious concern as it is extremely difficult to eradicate (Batish et al 2011). The plant has recently been reported to grow luxuriantly as a ground cover weed, though restricted to small patch sizes, in the rapidly urbanizing metropolitan city of Kolkata (Banerjee et al 2016). Because urban areas are more prone to alien species invasion due to the presence of highly disturbed and fragmented heterogeneous landscapes (Wang et al 2011), it is likely that the plant may expand its range and become a community dominant.

Numerous studies have tried to identify the reason behind the profound shifting of ecological fortunes of an invasive species from being a minor component of the community (native range) to becoming a community dominant in its introduced range (Callaway and Maron 2006). Understanding the mechanisms that enable a plant to establish successfully in a novel habitat is an important area of ecological research (Leishman et al 2007). Among the various mechanisms known, phenotypic plasticity, usually defined as the ability of the same genotype to express different phenotypes in response to different environmental conditions (Pigliucci 2001), has been identified to be a major one (Davidson et al 2011). This property of an invasive plant to modulate its biological and ecological traits may consequently broaden its habitat niche in the invaded range enabling it to grow and reproduce in a wide range of environmental conditions (Hejda et al 2009; Joshi et al 2001; MacNally 1995; Pyšek and Richardson 2008; van Kleunen et al 2010). Modification of species-level traits has also been associated

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with the flexibility of an invasive species to respond to a rapidly changing environment (Kauffman and Jules 2006), which helps the exotic plant to outcompete the resident vegetation, enabling it to become an invader in the community (van Kleunen and Richardson 2007). Several examples have been found in the literature in support of phenotypic plasticity in plants in response to different environmental fluctuations, for example, sun versus shade leaves (Vogel 1968), competition (Turkington 1983), or soil nutrient availability (Lehmann and Rebele 2005).

Trait-based community ecology studies involving *M. micrantha* have focused largely on interspecific trait differences. For example, *M. micrantha* has been found to have higher photosynthetic activity, more efficient water and nitrogen use efficiency (Deng et al 2004), and low leaf construction cost (Song et al 2007) in comparison to the natives as well as congener species. However, the importance of intraspecific trait variation for community assembly and ecosystem processes has recently been demonstrated (Siefert et al 2015; Violle et al 2012). Intraspecific trait variation between individuals within a species reflects both genotypic variation and phenotypic plasticity. This variation influences plant responses to abiotic filters and biotic interactions (Fridley et al 2007; Fridley and Grime 2010) as well as plant effects on ecosystem processes (Crutsinger et al 2006; Hughes et al 2008), which helps to make inferences about local community assembly processes (Jung et al 2010; Paine et al 2011; Siefert 2012). Intraspecific trait-based analysis has revealed physiological adaptation of *M. micrantha* traits (in terms of photosynthetic ability) in altitudinal differences (Prabu et al 2014). However, a notable gap exists on the characterization of this perennial plant's ability to maintain its population on a spatiotemporal scale. This is more relevant in tropical and subtropical countries where seasonal differences in both light and water availability may contribute to variability in plants' traits, especially those related to water relations and leaf economics. Moreover, strong seasonality may cause trait relationships at the local scale to differ from those found in continental and global scale (Gotsch et al 2010). Thus, understanding the influence of season and habitat factors on the overall fitness of *M. micrantha* becomes relevant. In this context, it can be hypothesized that the survival ability of *M. micrantha* is a function of plasticity of its fitness-related traits, which enables the plant to survive and maintain its population throughout the year.

A number of controlled experiments have highlighted the negative impacts of *M. micrantha* on native plant species richness (Day 2012; Ismail and Chong 2002; Kaur et al 2012). These impacts of an exotic species may not be uniformly detrimental (Santos et al 2011) because abiotic factors (e.g. seasonal fluctuations, habitat heterogeneity, and resource availability) can influence both native and exotic species richness in the community. However, to the best of our knowledge, no studies characterizing the impacts of *M. micrantha* on community composition incorporating abiotic factor have been conducted.

In view of the aforementioned information, this study was therefore conducted (1) to investigate the seasonal and habitat differences on the abundance of *M. micrantha* (in terms of cover percentage); (2) to elucidate plastic response of some pertinent morphological, biochemical, and physiological above-ground traits in different seasons and habitats; and (3) to identify the influence of abiotic (seasons and habitats) and biotic (abundance of *M. micrantha*) factors on community composition.

Materials and methods

Site description

The study was carried out in the Greater Kolkata region, within an undisturbed plot with abundant *M. micrantha* growth (88°22′15.66″E, 22°39′20.48″N), during 2013–2014 covering the three major seasons (summer: March–June; monsoon: July–October; and winter: November–February). The summary of the daily meteorological data, obtained from Regional Meteorological Center, has been presented in Figure 1. The average maximum temperature ranged from 27.8°C in winter to 34.6°C in summer, whereas the range of average minimum temperature was 15.7°C in winter to 26.1°C in monsoon. The highest average rainfall was recorded during the monsoon season (9.07 mm).

The plot also included a pond, thus contributing to three habitat types for *M. micrantha* growth, namely, the littoral region of the pond, an intermediate region at a small distance from the pond, and the terrestrial region (farthest from the pond). To ensure representative sampling, three sites considered to be replicates for each habitat were chosen with a minimum distance of 10 m between sites for each habitat type (Figure 2).

Plant sample collection and identification

The community composition within a 1 m^2 quadrat was recorded monthly in each site for all habitat types. The major plant was identified as *M. micrantha* from the Botanical Survey of India (BSI), and an herbarium specimen was deposited at the Central National Herbarium, BSI (Specimen number: ISI/AB/01). The associated plants occurring with *M. micrantha* were noted and unknown species were sampled and identified from BSI. The native region of the plant species was ascertained from the Invasive Species Specialist Group (www.issg.org/database/welcome/) and the Indian Society of Weed Science (http://www.isws.in/invasive-plants-of-india.php) databases.

Estimation of plant cover and traits

The percent cover of *M. micrantha* was visually estimated monthly from three randomly placed 1 m^2 quadrats in each site for all habitat types. Because the primary objective of this study was to characterize the phenology of the plant at a temporal scale, destructive sampling within a quadrat (for estimation of above-ground biomass) would hamper the regular growth cycle of this

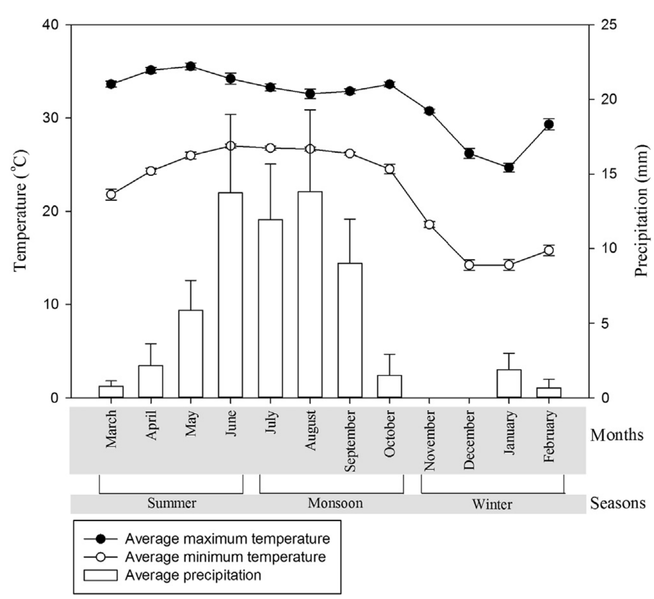

Figure 1. Meteorological data in terms of monthly average of maximum and minimum temperature and rainfall (March 2011–February 2012).