Profile of an Invasive Plant: Mikania micrantha

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Introduction

Despite the long history of biological invasions in the Asia–Pacific region, little has been achieved in terms of effective management actions for such species. This situation needs be remedied given that: (i) many crop species are affected, thereby threatening the food security of all countries in the region; (ii) the region has a great diversity of habitats, rich biodiversity and a high level of species endemism; (iii) many endemic species and their habitats in the region are threatened; and (iv) the degradation and fragmentation of natural habitats are common. Thus, damage due to invasive alien species is arguably higher in this region than in other parts of the world.

Although the threat posed by invasive species to livelihoods and biodiversity is now high profile, the mechanisms by which an invasive species succeeds are largely ill-defined. A fundamental understanding of these mechanisms might eventually allow the prediction of which species will become invasive and, therefore, the development of more effective management strategies (Deng et al., 2004). Nevertheless, at present it remains difficult to predict whether a species that establishes in a new environment will become invasive or not. The best predictors of invasiveness for plants are whether the species has such a history elsewhere and whether it reproduces vegetatively (Kolar and Lodge, 2001), but neither of these predictors is appropriate with newly invasive species. However, there are some general factors that are either likely to operate or known to be important in facilitating an exotic species to become invasive: for example, similarities in climate and soil between the original habitat of the exotic species and its new habitat (Nye and Greenland, 1960; Holgate, 1986); and the absence of all or most of its co-evolved, host-specific natural enemies (which were present in the original habitat) from the adventive range (as mentioned in the next paragraph).

Some of the most damaging invasive alien species are plants. Plant species have been moved around the world by humans for centuries – either deliberately as crops and ornamental species, or accidentally as casual passengers. Most of these species do not become invasive in their introduced range. Moreover, plants are usually moved without most or all of the natural enemies referred to above, and, often aided by human disruption of natural habitats, population explosions of some species occur, with the subsequent development of plant invasions (Mack et al., 2000). The Neotropical plant Mikania micrantha Kunth illustrates the latter situation very well, and it is used as a core example by most of the authors in this volume. In its native range, the species generally has a cryptic riparian non-weedy habit, and grows along riverbanks and among reed-like vegetation around standing water (Cock, 1982; Barreto and Evans, 1986; Rejmanek, 1989; Kolar and Lodge, 2001).
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None the less, since the plant was introduced into Asia at various times in the 20th century as a cover crop, and for various other purposes (see next section: Taxonomy, description and distribution), the environments in Asia and the Pacific have allowed it to express a full, or near-full, capacity for reproduction, growth and spread across many types of ecosystems. As a result, *M. micrantha* has become a serious threat to a range of crop plants and to native plants, particularly in India in the high-biodiversity areas of the Western Ghats and in the state of Meghalaya (Bhatt et al., 2012; and Chapter 1, this volume).

Here, current information on the taxonomy and distribution of *M. micrantha* are summarized, followed by a review of relevant details on its life cycle and physiological ecology. The last of these topics has received much attention over recent years and advances have been made in particular on the allelopathic properties and photosynthetic strategy of the plant. Additional information about its physiology has been elucidated from a comparison with *M. cordata*, which is native to Asia (Deng et al., 2004). These topics form an important backdrop for the book, because the theme of how some of the plant’s biological traits have facilitated population outbreaks in agro-ecosystems and disturbed native ecosystems owing to the nature of these habitat types is pursued by authors in a number of chapters in this volume. The topic of the role of the natural enemies in suppressing plant invasions is discussed separately in Chapter 10, this volume.

Lastly, another consequence of the domination of *M. micrantha* in many habitats in the Asia-Pacific region is that several rural communities have been driven to seek ways of exploiting the plant, and these have been largely based on its perceived traits and properties. The reported benefits are few, but they are reviewed at the end of this chapter in order to complete the species profile.

A general data sheet on *M. micrantha* can be found in the open-access CABI Invasive Species Compendium (available at: www.cabi.org/isc/datasheet/34095).

### Taxonomy, Description and Distribution

*M. micrantha* was described in 1818 by Kunth (Humboldt et al., 1818). Common English-language names for the species include mikania weed, American rope, bit-tervine, climbing hemp vine and Chinese creeper. Although it is also commonly called mile-a-minute weed, this name is best avoided as it is also used for the unrelated weed *Persicaria perfoliata* in the USA. The classification of the species is as follows:

- **Class:** Dicotyledonae
- **Subclass:** Asteridae
- **Order:** Asterales
- **Family:** Asteraceae (Compositae)
- **Subfamily:** Asteroideae
- **Tribe:** Eupatorieae
- **Species:** *Mikania micrantha* Kunth

*Mikania* is a species-rich genus with over 425 described species (King and Robinson, 1987). Almost all are New World native species, with only nine being considered native to the Old World, and only one of these, *M. cordata* (Burm. f.) Robinson, being native to Asia (Holmes, 1982). There has been considerable confusion over the correct identification of *M. micrantha* in Asia, with early literature mistakenly referring to it as *M. scandens* (L.) Willd. (a North American species) or *M. cordata*. However, Parker (1972) concluded that *M. micrantha* is the only species that causes a significant weed problem, and this was confirmed by the work of Holmes (1982).

*M. micrantha* is a fast-growing, perennial, creeping or twining vine. A full taxonomic description from Holm et al. (1991) is as follows:

- **stems** branched, pubescent to glabrous, ribbed; **leaves** opposite, thin, cordate, triangular, or ovate, blade 4 to 13 cm long, 2 to 9 cm wide, on a petiole 2 to 8 cm long, base cordate or somewhat hastate, tip acuminate, margins coarsely dentate, crenate, or subentire, both surfaces glabrous, three- to seven-nerved from base; **flowers** in heads 4.5 to 6 mm long, in terminal and lateral openly rounded, corymbous panicles; **involucral bracts** four,
oblong to obovate, 2 to 4 mm long, acute, green, and with one additional smaller bract 1 to 2 mm long; four flowers per head; corollas white, 3 to 4 mm long; fruit in an achene, linear-oblong, 1.5 to 2 mm long, black, five-angled, glabrous; pappus of 32 to 38 mm long, soft white bristles 2 to 3 mm long.

The species possesses semi-translucent enations (small scaly leaf-like structures without vascular tissue) between the petioles at the nodes of young vegetative shoots, which are a rare feature in the Asteraceae. These are not seen on flowering branches and they wither on older shoots. Differences in the form of the enations can help to distinguish *M. micrantha* from *M. cordata*. The enations of *M. micrantha* are membranous flaps with incised lobes, whereas *M. cordata* produces ear-like enations with furry ridges, which are not membranous (see Fig. 2.1a).

The length of the pappus (the fine feathery hairs that surround the fruit in the Asteraceae) bristles on the seed is also a distinguishing feature between the two species. Fig. 2.1b shows the structure of *M. micrantha* seed, which has pappus bristles that are 2–3 mm in length, while those of *M. cordata* are significantly longer (4–5 mm) and the seed is significantly larger. *M. micrantha* is a plant of Neotropical origin that has become invasive in most countries within the humid tropical zones of Asia and the Pacific (Waterhouse, 1994). It occurs from sea level up to 1500 m. The first record of *M. micrantha* in Asia dates back to 1884, and is from the Hong Kong Zoological and Botanical Gardens (Li et al., 2003). However, in Malaysia and Indonesia, evidence suggests that the plant was introduced on a number of occasions, both to botanical gardens and as a plantation cover crop (Wirjahardja, 1976; Holmes, 1982; Cock et al., 2000). It was recorded to have been brought from Paraguay to Bogor Botanical Garden in West Java, where it was planted for medicinal purposes in 1949 (Cock et al., 2000). Some scientists support the view that *M. micrantha* was introduced as a non-leguminous ground cover for crops in India (Borthakur, 1977; Palit, 1981), and Parker (1972) reported that the plant was intentionally introduced into north-eastern India during the Second World War as ground cover.
cover in tea plantations. In addition, anecdotal evidence suggests that it was used for airfield camouflage in Assam during World War II (A.C. Barbora, Assam Agricultural University, 1999, personal communication).

The species is native to the tropical and subtropical zones of Central and South America, from Mexico to Argentina. It is widespread, but is not recorded as a significant weed in its native range. Its status in the Asia–Pacific region is shown in Fig. 2.2; further more detailed country-specific distribution is covered in some of the chapters in this volume. *M. micrantha* is currently under an ‘eradication programme’ in Queensland, Australia (Brooks et al., 2008), and has been reported as a noxious weed in Florida, USA (Derksen and Dixon, 2009).

**Life Cycle**

*M. micrantha* has a vigorous capacity for both vegetative and sexual reproduction (Swamy and Ramakrishnan, 1987a), but cannot tolerate dense shade (Holm et al., 1991). It occurs largely in humid environments and at temperatures between 13 and 35°C. Seed production by a single plant can reach 20,000–40,000 achenes (one-seeded fruits) in one season (Dutta, 1977) and these are dispersed long distances by wind (Holm et al., 1991). The species is also able to produce perennating organs (rosette roots) for survival during less favourable conditions and ramets form from these rosettes when conditions allow active growth. In addition, the plant can grow vegetatively from very small sections of stem (Holm et al., 1991). The growth of young plants is extremely fast – an increase of 8–9 cm has been recorded in 24 h (Choudhury, 1972) – and they will use trees and crops to support their growth. In the Asia–Pacific region, these features result in the plant rapidly forming a dense cover of entangled stems bearing many leaves (Holm et al., 1991). Areas freed from the plant by slashing can be recolonized within a fortnight (Choudhury, 1972). Damage is caused to crops because the weed can smother, penetrate crowns, choke and even pull over other plants.

Ramakrishnan and Vitousek (1989) reported that within its native and adventive ranges, *M. micrantha* occurs in humid tropical areas with highly leached soils. More recent work in China, however, shows that

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**Fig. 2.2.** Distribution of *Mikania micrantha* in South-east Asia. Adapted from the CABI Invasive Species Compendium distribution map in South East Asia and the Pacific. Available at: http://www.cabi.org/isc/datasheet/34095.
the plant commonly grows on a wide range of soils – from acidic to alkaline (pH 4.15–8.35) and with a broad range of relative proportions of organic matter (Zhang et al., 2003). Under some circumstances, the plant also successfully competes for soil nutrients, while there is evidence from several studies that the weed can retard plant growth through the production of allelopathic substances (see next section).

**Physiological Ecology**

**Allelopathic properties**

Allelopathy is considered to be an important mechanism in successful exotic plant invasion. There is evidence from several studies that *M. micrantha* can retard plant growth through the production of allelopathic substances (Holm et al., 1991; Cronk and Fuller, 1995) and this may be an important factor driving its invasion success in the Asia–Pacific region. The evidence falls into two categories: the properties of the *M. micrantha* rhizosphere soil; and the effects of the application of extracts of *M. micrantha* tissue on other plants.

Chen et al. (2009) found that soil in which *M. micrantha* had been growing inhibited the seed germination and growth of test plants and, in addition, had higher nutrient levels. *M. micrantha* has also been shown to have a disproportionately larger impact on the growth of young cocoa than weedy *Cyperus* spp. or *Imperata cylindrica* (Zaenuddin et al., 1986). Gray and Hew (1968) reported a similar effect in oil palm; they found a 20% reduction in yield due to *M. micrantha* when it was used as a cover crop, and even when fertilizer was applied there was still an 11% yield reduction. This suggests that *M. micrantha* has an impact on growth through both competition for nutrients and direct allelopathic effects. Kaur et al. (2012) found that rice seedling growth is suppressed in *M. micrantha* rhizosphere soil; they found higher levels of organic matter, organic nitrogen and water-soluble phenolics in soil in which the plant had been growing compared with soil from which the plant was absent. Further, these authors found lower soil respiration in the *M. micrantha* rhizosphere and suggested that this may be due to a higher ratio of fungal/bacterial biomass in the soil.

Even as mulch, leachates of *M. micrantha* can adversely affect the growth of other plants. Ismail and Mah (1993) found that the leachates caused a significant reduction in the growth of three weed species, and Abraham and Abraham (2006) attributed the inhibition of rubber seedling growth by *M. micrantha* mulch and extracts to allelopathy. In a pot experiment with young rubber seedlings, Shao et al. (2005) isolated and identified three sesquiterpenoids from the aerial parts of *M. micrantha* which inhibited germination and growth in *Acacia mangium*, *Eucalyptus robusta* and *Pinus massoniana* in natural habitats in southern China.

Clearly, more work is needed to better understand the mechanisms involved, and the scale of impact and range of plants affected, as this would facilitate the improvement of management options for *M. micrantha*.

**Photosynthetic strategy**

The mechanisms of photosynthesis differ between plants. The two main types of photosynthesis are usually referred to as C$_3$ (c.90% of plant species) and C$_4$ (c.10%) (see Box 2.1); this is because the CO$_2$ is fixed by initially incorporating it into either a 3- or 4-carbon compound, respectively. In tropical weed communities in a variety of systems – such as smallholdings, plantations and shifting agriculture – both C$_3$ and C$_4$ plants are found. For example, of the predominant weeds in the early fallow stage in the shifting agriculture of north-eastern India, the most important exotic species, including *M. micrantha*, are C$_3$ plants, while all of the important native plants are C$_4$ species (Saxena and Ramakrishnan, 1984a).

Although C$_4$ plants are generally regarded as better adapted to hot environments with high light intensity,
M. micrantha and many other exotic invasive tropical C₃ plants are also able to predominate. At least part of the explanation for this apparent paradox is that C₄ photosynthesis comes at a cost in terms of the investment of resources in the cell structures and biochemical pathways involved. In some circumstances, this can give C₃ photosynthesis a competitive edge. Furthermore, unlike other exotic C₃ weeds such as Chromolaena odorata, which rely largely on heavy seed production (Kushwaha et al., 1981), M. micrantha also reproduces easily by vegetative propagation (Swamy and Ramakrishnan, 1987a).

Research illustrating how the properties of M. micrantha and other C₃ plants can confer competitive advantages over native plants under certain circumstances was carried out in the shifting agriculture systems in the hill regions of north-eastern India by Ramakrishnan and several co-workers. In summary, three main important situations were identified:

- **Variation in light intensity over the year.** C₄ photosynthesis is at its peak in the higher light intensity and thus temperatures in the middle of the year in the region, coinciding with the start of the growing season (April–June), and growth by C₄ species is strongest at this time (Saxena and Ramakrishnan, 1984b). In contrast, with light intensity and temperatures falling during the latter part of the growing season (October–December), C₃ photosynthesis comes into its own and these species grow more strongly (Saxena and Ramakrishnan, 1984a).

- **Variation in nutrient availability.** Leaching and erosion on the steep slopes where shifting agriculture is practised means that soil nutrients are not evenly distributed (Toky and Ramakrishnan, 1981). The nutrient-poor higher slopes are occupied by C₄ species, while the lower slopes where nutrients have accumulated are occupied by C₃ species (Saxena and Ramakrishnan, 1983, 1984a).

- **Fire.** Soil fertility status may increase after burning (which is done to prepare land for planting) and the increase would be to a greater extent in older fallows because of their increased fuel loads. This would tend to favour the growth of the C₃ species, which are more efficient at nutrient uptake, when the light intensity and temperature also favour the growth of these species (Swamy and Ramakrishnan, 1987a,b, 1988a,b).
These and other dimensions of C₃ plant invasions in shifting agriculture are reviewed in detail in Chapter 7, this volume.

The Photosynthetic Strategy of *Mikania micrantha* Compared With *M. cordata*

In southern China, the non-invasive *M. cordata*, which is native to the Asia–Pacific region, has been displaced by *M. micrantha* (Deng et al., 2004). Superficially, *M. micrantha* and *M. cordata* appear to be very similar in their morphologies and life histories (which has led to them being confused). However, *M. cordata* grows more slowly and only in shaded habitats, and does not achieve weed status; *M. micrantha*, in contrast, is highly invasive in open, disturbed habitats, including home gardens, plantations, abandoned cultivated land and forest gaps.

In seeking the mechanisms underlying these differences between the two species, Deng et al. (2004) looked at whether *M. micrantha* had a greater capacity for photosynthesis or used resources more efficiently than its non-invasive relative. These authors demonstrated a number of key differences between the two plants:

- **At high light levels**, *M. micrantha* photosynthesizes at a higher rate than *M. cordata*. Conversely, the two species photosynthesize at similar and lower rates at lower light levels. Thus, at high light levels, *M. micrantha* assimilates CO₂ at a higher rate, with associated higher photosynthetic enzyme activity. *M. micrantha* also fixes CO₂ at higher concentrations inside the leaf than does *M. cordata*, so it creates a larger pool of organic carbon for use in growth and reproduction.

- **M. micrantha** uses fewer leaf resources for photosynthesis than *M. cordata*. ‘Leaf nitrogen’ is a common proxy for investment in photosynthesis (as enzymes, cell structures), and *M. micrantha* photosynthesized more rapidly than *M. cordata* across a range of leaf nitrogen levels, indicating that it made more efficient use of this investment (and so was left with more for growth and reproduction).

- **M. micrantha** has greater CO₂ uptake for less water loss through the stomata than *M. cordata*. This greater ‘water-use efficiency’ indicates that faster photosynthesis by *M. micrantha* is not achieved by keeping its stomata open to take in more CO₂. The authors highlighted that *M. micrantha* combines this characteristic with high resource (photosynthetic nitrogen) use efficiency, rather than needing a trade-off, most likely because of its highly efficient photosynthesis.

- **M. micrantha** has a larger area of leaf per unit weight (specific leaf area) than *M. cordata* – in other words, it has relatively large thin leaves – a trait that has been linked by other authors to greater light capture and CO₂ uptake.

- The ‘construction costs’ are lower for *M. micrantha* leaves. So even though it creates more photosynthetic products, it uses fewer of them in photosynthesis itself.

In summary, Deng et al. (2004) showed how *M. micrantha*’s leaf physiology and morphology allow it to exploit more open, drier habitats than *M. cordata*; the structure and function of its leaves facilitate faster and more efficient photosynthesis at higher light levels, allowing it to assimilate more CO₂ without compromising its water balance.

**Beneficial Effects of *Mikania micrantha***

Although widely introduced into Southeast Asia and the Pacific as a cover crop, *M. micrantha* is considered to be of restricted value, particularly when compared with nitrogen-fixing legumes such as *Mucuna bracteata* (Teoh et al., 1985). Cattle eat it, but its nutritional value is considered to be inferior to that of the pasture plants it is able to smother; and it is known to cause hepatotoxicity and liver damage in dairy cattle. Owing to its sprawling nature, the species has been used to prevent soil erosion and to serve as mulch. It is considered by some to
be less noxious than those weeds that might occupy a particular niche if it were not present (Waterhouse, 1994).

In villages in Indonesia, besides being slashed as herbage, M. micrantha is used as a poultice for swellings, itching and wounds. A similar practice is reported from some Pacific island countries (see Chapter 6, this volume); reports from Fiji indicated that the leaves were applied as a poultice for ant bites and hornet and bee stings as early as the 1950s (Parham, 1958). Biological control measures in Western Samoa are being delayed while a perceived conflict of interest is addressed: M. micrantha leaves are used medicinally, and there is a perception that the release of a biocontrol agent would have an impact on the amount of plant material available. In addition, there has been a perception among farmers that M. micrantha is a good mulch and easier to control than other weeds, as well as being ‘good’ for the soil and reducing other pests. This view is held despite much time being spent by family members in controlling the weed and preventing it from smothering crops such as cocoa, taro, bananas and papaya, as these types of activities by family members are not considered to be a ‘cost’ by farmers (Ellison et al., 2014). Day et al. (2011), in a socio-economic study in Papua New Guinea, reported that 32% of respondents used M. micrantha as a medicinal plant to treat cuts and wounds. Baruah and Dutta Choudhury (2012) included M. micrantha among the medicinal plants used in the Barak Valley of Assam in north-eastern India.

Other work has shown the potential of M. micrantha extracts as an insect deterrent. Cen et al. (2003) found that alcohol extracts of the plant inhibited oviposition by the citrus leaf miner (Phyllocnistis citrella), and Zhang et al. (2004) showed that essential oils extracted from M. micrantha had oviposition deterrent and repellent properties against the diamondback moth (Plutella xylostella). Studies have also highlighted insecticidal properties of the plant against several agricultural pest species. Methanol extracts of M. micrantha have shown potential as insect growth regulators for the rhinoceros beetle (Oryctes rhinoceros) (Zhong et al., 2012); these authors showed that including the extracts in beetle food had a feeding deterrent effect but also delayed development and increased mortality at all developmental stages, as well as leading to deformities. Lu et al. (2012) found that alcohol extracts of M. micrantha caused developmental delay and increased deformities in the coconut leaf beetle (Brontispa longissima) and reported 80% control in semi-field trials.

In its native range, there are unsubstantiated reports of the use of M. micrantha in folk medicine as a cure for snake bites (R.W. Barreto, Universidade Federal de Viçosa, Brazil, 1991, personal communication). Evidence has emerged more recently of other significant medicinal potential of the species. Investigations by Bakir et al. (2004) led to the isolation of mikanolide compounds from a variety of M. micrantha growing in Portland, Jamaica. The mikanolides have been shown by Teng et al. (2005) to have potential for treating cancer, and the authors have patented (in the USA) a method of treating proliferative diseases (cancers) in warm-blooded animals by administering an appropriate amount of at least one compound selected from the sesquiterpenoid group consisting of mikanolides and dihydromikanolides.

While these potential benefits should not be discounted and may lead to various uses for M. micrantha, the available evidence to date clearly indicates that the damage caused to crop and forest tree production and to native biodiversity far outweighs these benefits.

Conclusions

An increasing amount of research over recent decades has revealed much about the physiology and ecology of M. micrantha and this has provided a clearer basis for understanding how and why this plant has become invasive in so many agricultural and native ecosystems. The main biological traits and features of the plant, which are summarized in Box 2.2, may not substantially
differentiate it from other indigenous sprawling vines. However, though it may have competitive advantages, having evolved in isolation from the indigenous fauna of the Asia–Pacific region, there is also strong evidence that the absence of specialized natural enemies following its introduction from the Neotropical region is also critical (Cock et al., 2000). This aspect is further discussed in Chapter 10, this volume.

References


Box 2.2. The main biological traits and features of Mikania micrantha.

- Native to the New World tropics, M. micrantha is a highly invasive weed in the Asia–Pacific region of the Old World, where it smothers other vegetation; it occurs from sea level up to 1500 m, and at temperatures of between 13 and 35°C.
- It is a fast-growing, perennial vine that is able to smother plants in agricultural ecosystems, agroforestry and plantation systems and natural habitats, thereby reducing productivity and biodiversity.
- It grows in a wide range of soil types – from acid to alkaline, but does not tolerate shade.
- Its seed production is prolific, and the seeds are predominantly wind dispersed as they are light in weight. The seeds have no dormancy and are an effective means of propagation in unutilized, cleared or burnt ground. The plant also reproduces vegetatively rather vigorously – new plants can develop from nodes, which produce roots when in contact with damp soil.
- The plant has allelopathic properties, but the mechanism of this action is unclear.
- The rapid photosynthesis exhibited by M. micrantha, courtesy of a large leaf area and efficient biochemical pathways, means that it grows quickly, particularly in unshaded situations and at high light intensities.
- It is efficient at taking up nutrients where plenty are available, and accumulates them in its tissues, but it is not so good at sequestering nutrients when they are in short supply; thus, burning, which releases nutrients from the standing plant biomass and destroys shade, favours growth.


consequences and control. *Ecological Applications* 10, 689–710.


