

The invasion by *Mimosa pigra* of wetlands of the Mekong Delta, Vietnam

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Abstract

The Mekong River Delta is a wetland complex, covering an area of approximately five million hectares, of which about four million hectares are in Vietnam, the rest in Cambodia. Recent inventory showed that environmental weeds made up about 10% of the natural flora of the Mekong Delta. Of those alien plants, mimosa, *Mimosa pigra* L., is among the most serious. This paper provides a synopsis of mimosa invasion on wetlands of the Mekong Delta, and discusses its distribution, habitat preference, morphology, phenology, seed bank, proliferation and current efforts to control mimosa in two wetland national parks, Tram Chim (Dong Thap Province) and U Minh Thuong (Kien Giang Province).

The first record of mimosa in the Mekong Delta was collected in 1979 in Moc Hoa District, Long An Province. The weed is now found in all 12 provinces of the Mekong Delta, mostly in the freshwater region influenced by floodwater from the Mekong River. A map of mimosa infestation areas in the Mekong Delta is provided, together with discussions on habitat preference and measurements of plant biological characteristics. The invasion by mimosa has been monitored in the two national parks since 1999. At U Minh Thuong, the invasion of mimosa was detected early, and the eradication was completed with little cost, using manual removal methods. At Tram Chim, however, the infestation has increased beyond easy management. Since 2000, the infestation area in Tram Chim has doubled every year. Maps of mimosa in Tram Chim 2000–2002 are presented. Experiences with mimosa in Tram Chim and U Minh Thuong demonstrate that awareness and early intervention are key factors of a successful weed-management program, particularly in the context of developing countries where there is often a lack of funding and expertise for comprehensive weed control practices.

Keywords: distribution, spread, mimosa biology.

Introduction

Mimosa pigra L., is one of the worst environmental weeds of the Mekong River basin

(Storrs *et al.* 2001). It is a weed in Cambodia and Vietnam (Lonsdale 1992) and has been a serious weed in Thailand since the early 1980s (Napompeth 1983). At that time, however, the weed was perhaps not widespread in areas further downstream in the Mekong. The first botanical record of mimosa in the Mekong Delta was collected in Moc Hoa District, Long An Province, Vietnam, in 1979 (University of Natural Sciences, Ho Chi Minh City, herbarium archive) at a time when the weed

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was still uncommon. Opinions from local experts during an international workshop on mimosa management for the lower Mekong basin held in Phnom Penh, Cambodia in 2001, was that mimosa was widespread in most of the lower Mekong basin by the late 1990s (Figure 1).

The Mekong Delta is a large wetland complex, covering approximately five million hectares in both Cambodia and Vietnam. It is a low and flat plain with average elevation of 1 to 1.5 metres above the mean sea level. The climate is monsoonal with the dry season from December to May and the rainy season from June to November. Average annual rainfall varies between 1,500 mm and 2,200 mm across the Delta. At the peak of the rainy season, about two-thirds of the Delta is inundated by the Mekong floodwater. In the recent history of Vietnam, the Mekong Delta is a newly developed area. Land reclamation was sped up during the 1980s and 1990s. The pace of reclamation, however, was very fast. During 1990s, the Mekong Delta lost at least 90% of its natural floodplain wetlands, mostly to rice paddies. A dense network of canals was built to drain wetlands and to supply rice fields with freshwater. Canals created environmental disturbances that favoured

the spread of exotic weeds, including mimosa. Recent weed surveys recorded 76 environmental weeds (approximately 12% of non-cultivated flora) occurring in areas of the Mekong Delta, of which mimosa is among the most invasive (Triet 2000, Storrs *et al.* 2002).

This paper presents the status of mimosa infestation, habitat reference and some biological characteristics of mimosa plants growing in the Mekong Delta. This information resulted from field surveys and experiments carried out by the University of Natural Sciences, Ho Chi Minh City, between 1999 and 2002.

Methods

Distributional range and habitat preference

The distribution of mimosa in the Mekong Delta was recorded during field surveys, as well as in combination with other botanical surveys. Detailed surveys were conducted in the Mekong Delta conservation areas, including in the two national parks, Tram Chim and U Minh Thuong (Storrs *et al.* 2002).

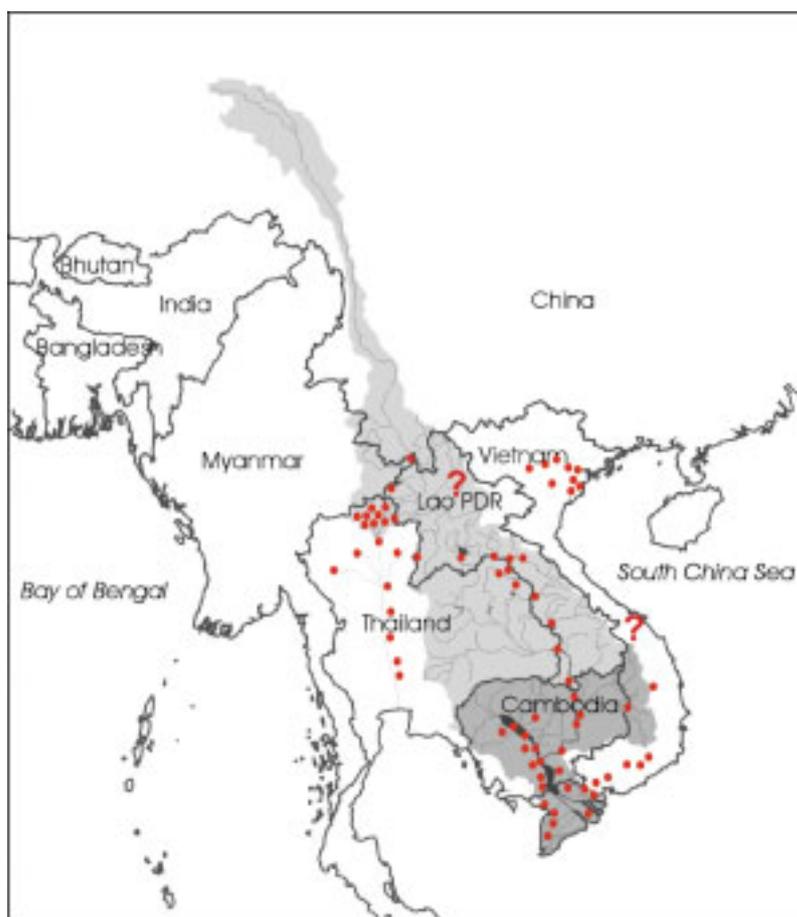


Figure 1. Map of the Mekong River basin (shaded area) with red dots showing known occurrence of mimosa (Storrs *et al.* 2001).

Biological characteristics

All field observations and measurements on biological characteristics of mimosa were performed in Tram Chim National Park, Dong Thap Province. Information on plant size and above-ground biomass was collected from 100 plots, size 10 m × 10 m, randomly placed in two types of mimosa habitats: earth dikes and grasslands. Earth dikes are 1.5 to 2.0 metres higher than grasslands and therefore have shallower standing water and shorter inundation time during the flood season. Numbers of infructescences per stem were measured in both dry and wet seasons to determine the major fruiting season.

To determine their density and viability mimosa seeds in the topsoil were collected from 34 sampling sites in Tram Chim National Park. Sample sites were stratified to three levels of mimosa infestation: dense (canopy coverage of more than 70%), sparse (canopy coverage 10–30%) and no mimosa present. At each sampling site, the top 10 cm soil layer was collected in four plots of

size 0.5 m × 0.5 m. Samples from four plots were put together to make a composite sample that represented number of seeds per square metre. Seed viability was determined by staining seed tissue with tetrazolium (triphenyltetrazolium chloride) and indigocarmin. One positive result from the two tests indicated that the seed was viable (Sutherland 1996).

Chemical tests were performed at the general chemistry laboratory of the University of Natural Sciences, Ho Chi Minh City, to quantify basic chemical parameters and to determine the components of fatty acids in mimosa seeds.

Results and discussion

Distribution of mimosa in the Mekong Delta

Mimosa is now found in all 12 provinces of the Mekong Delta, but concentrated mainly in the freshwater zone (Figure 2). Upstream provinces of Long An, An Giang, and Kien Giang are most heavily



Figure 2. Map of mimosa infestation area in the Mekong Delta 2002 and locations of Tram Chim and U Minh Thuong national park.

infested. *Mimosa* was also found in the northern part of the Delta in Cambodia: Takeo, Kendal and Sway Rieng provinces. It is also reported infesting Tonle Sap Lake in Cambodia (Storrs *et al.* 2001). *Mimosa* is spreading in the Mekong Delta at a fast pace. Botanical records show that in the early 1980s the weed was still uncommon in the area. Within 20 years, *mimosa* has invaded large areas, forming dense stands in many places. The areas of highest *mimosa* density are also the ones that are subject to flooding every year. Fast-moving surface water along channels is perhaps the most important seed dispersal mechanism.

Habitat preference

In the Mekong Delta, *mimosa* is found commonly along water edges of ponds, streams, rivers and canals. It is found mainly in the freshwater zone, much less common in brackish water, and not found in the saline zone. *Mimosa* is highly invasive in lowland areas, particularly in seasonally inundated grasslands. The weed is common in public lands, such as those in protected areas, roadsides, canals, and streams. It is not abundant in croplands, such as rice fields and gardens, perhaps due to regular control by landowners.

Invasion of *mimosa* in biodiversity conservation areas

The invasion of *mimosa* in protected areas of the Mekong Delta has caused serious concerns. The Mekong Delta of Vietnam has nine protected areas, including two national parks and seven nature reserves. Except for four mangrove, protected areas, *mimosa* was found in all five protected areas located in the freshwater zone. The level of infestation is different between locations. The most heavily infested location is Tram Chim National Park, one of a few remnant wetlands located in the floodplain of the Delta. Tram Chim contains a mosaic of seasonally inundated grasslands, freshwater swamp forests dominated by *Melaleuca cajuputi* Powell and permanent water holes and streams. Grasslands in Tram Chim provide one of the most important dry-season habitats of the endangered Eastern Sarus Crane population in Southeast Asia. The first *mimosa* plants were seen in Tram Chim in 1984 (Nguyen Van Hung, head of the technical office, Tram Chim National Park, pers. comm.). In May 2000, the area of infestation was 490 ha and increased to 1846 ha in May 2002 (Figure 3). Between 2000 and 2002, *mimosa* doubled its area every year (Table 1). Despite warnings from weed experts, very little has been done in Tram Chim to control *mimosa*, and now the infestation has gone beyond easy management (Triet *et al.* 2001, Storrs *et al.* 2002). At the current rate of

spread, and if there is no improvement in weed control effort, *mimosa* is expected to invade all grassland areas of Tram Chim in less than five years, seriously jeopardising the life of native plants and animals that depend on grassland habitat.

Table 1. Area (in hectares) of *mimosa* infestation in Tram Chim National Park. A1, A2, A3, A4, A5 are names of five blocks of the core zone of Tram Chim.

	A1	A2	A3	A4	A5	Total
2000	108.05	126.84	19.01	97.05	139.20	490.16
2001	211.00	229.65	64.28	292.90	162.09	959.92
2002	535.79	318.56	117.50	377.00	497.00	1845.85

Mimosa management in U Minh Thuong National Park is a contrasting story to that of Tram Chim. In 2000, *mimosa* was found in two small spots with a total area of less than one hectare (Triet 2001). *Mimosa* seeds were probably brought into the site in construction sands. The infested areas were quickly treated by manual methods (hand pulling and stem cutting). Park management established a weed control team, which has been patrolling the park once a month since then to monitor *mimosa* and other important environmental weeds.

The different results between Tram Chim and U Minh Thuong demonstrate that early detection and intervention is a valuable tool in the management of alien invasive species, particularly in developing countries where there is often a lack of expertise and an insufficient investment in control measures (Triet *et al.* 2001).

Biological characteristics

Plant stature and above-ground biomass

Field observations made between 1999 and 2002, mostly in Tram Chim National Park, provided the following measurements (Table 2). Mean stem density was 2 stems m⁻². Canopy aerial coverage was 52.25% on average. Mean canopy height was 1.65 m, with maximum of 3.0 m. Mean stem height was 1.89 m, with a maximum height of 3.2 m. Stem heights of more than 5 m were also observed in areas where *mimosa* grew in *Melaleuca* forest stands. Mean fresh above ground biomass was 1118.20 g m⁻² (or 11.18 tonnes ha⁻¹) with a maximum value of 4,200 g m⁻² (or 42 tonnes ha⁻¹). Mean dry above-ground biomass was 679.4 g m⁻² (or 6.8 ton ha⁻¹), with maximum of 2810 g m⁻² (or 28 tonnes ha⁻¹).

Seed production

From a sample of 330 infructescences randomly collected from *mimosa* plants in Tram Chim, it

Table 2. Mimosa stem density, canopy coverage, canopy height, stem height, fresh and dry above-ground biomass, measured in Tram Chim National Park. T-tests showed no significant difference between two types of habitat in all parameters measured.

	Number of observations	Mean	Standard deviation	Maximum value
Stem density (stem m ⁻²)				
All	100	2.00	1.52	8.00
Dike	50	2.22	1.63	
Grassland	50	1.78	1.36	
Canopy coverage (%)				
All	100	52.25	32.70	100
Dike	50	50.30	31.34	
Grassland	50	54.20	34.22	
Canopy height (m)				
All	100	1.65	0.79	3.00
Dike	50	1.66	0.72	
Grassland	50	1.65	0.87	
Stem height (m)				
All	100	1.89	0.90	3.20
Dike	50	1.88	0.82	
Grassland	50	1.91	0.97	
Fresh biomass (g m ⁻²)				
All	100	1118.20	940.64	4,200
Dike	50	1022.20	839.39	
Grassland	50	1214.20	1031.65	
Dry biomass (g m ⁻²)				
All	100	679.40	610.51	2,810
Dike	50	637.70	574.23	
Grassland	50	721.10	647.89	

was calculated that the average number of pods per infructescence was 4.56, with a minimum of 1 pod and a maximum of 9 pods. The average number of seeds per pod was 16.6 (min: 7 and max: 21, standard deviation: 2.64). The average numbers of seeds per pod and pods per infructescence of mimosa plants in the Mekong Delta are smaller than those reported by Lonsdale (1992) in northern Australia (average 21.0 seeds per pod and 7.1 pods per infructescence).

Phenology

Even though mimosa flowers and fruits all year round in the Mekong Delta, the dry season (December to May) is the main fruiting season. In Tram Chim, in the dry season from late May to early June 2002, data from 60 mimosa plants averaged 15.54 infructescences per stem, with a range of 2 to 47. A sample of 60 mimosa plants taken in September 2001, in the wet season, averaged 4.76 infructescences per stem, range 1 to 14. In the wet season (June to November), Tram Chim is submerged under 2 m to 4 m of floodwater. It appears that a long period of inundation is an important factor inhibiting growth and reproduction of mimosa. It was observed, however, that the weed was able to flower and fruit even when most of the plant was submerged.

Soil seed bank

The average number of seeds in the topsoil was 100 m⁻². A maximum of 318 seeds m⁻² was observed. This is much smaller than an average of 12,000 m⁻² reported for a mimosa-infested area in northern Australia (Lonsdale 1992). The average seed viability (i.e. proportion of viable seeds in the seed bank) was 74%

Seed chemistry

Some basic chemical parameters and the concentration of fatty acids in seed tissues are provided in Tables 3 and 4.

Table 3. Mimosa seed chemistry.

Parameters	Mean (standard error)
Total ash	5.82% (0.05%)
Total carbohydrate	14.84% (0.08%)
Total nitrogen	32.85% (0.06%)
Soluble proteins	16.63% (0.18%)
Total lipid	18.76%
Acid coefficient	4.62 (0.02)
Saponin coefficient	200.60 (0.47)
Iodine coefficient	117.76 (0.12)



Figure 3. Map of mimosa infestation area in 2002 in Tram Chim National Park, Dong Thap Province, Vietnam.

Table 4. Percentages of fatty acids in mimosa seed oil.

Types of fatty acid		Percentage
Palmitic acid	C ₁₅ H ₃₁ COOH	10.14
Stearic acid	C ₁₇ H ₃₅ COOH	2.8
Oleic acid	C ₁₇ H ₃₃ COOH	39.36
Linoleic acid	C ₁₇ H ₃₁ COOH	40.76
Linolenic acid	C ₁₇ H ₂₉ COOH	6.1
Arachidic acid	C ₁₉ H ₃₉ COOH	0.39
Behenic acid	C ₂₁ H ₄₃ COOH	0.81

Acknowledgements

Tran Triet thanks the Australian International Seminar Support Scheme (ISSS) for sponsoring me to attend the symposium to present this paper.

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