

## **DAMAGE CAUSED BY *Merremia eberhardtii* AND *Merremia boissiana* TO BIODIVERSITY OF DA NANG CITY, VIETNAM**

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### **ABSTRACT**

About 2,000 ha of a special use forest in the Son Tra Nature Reserve and the protected forest at Nam Hai Van Pass, Da Nang City are severely affected by *Merremia eberhardtii*. This invasive woody vine has been rapidly spreading across these protected areas since 1999. In the near-by Ba Na Nui Chua Nature Reserve, about 300 ha of forest are affected by *M. boissiana*. In all locations these woody vines are climbing and covering the forest canopy, killing the trees and plants below by preventing them from absorbing sunlight. The presence of these invasive plants also heightens the risk of forest fires as their large, thick leaves catch fire easily, even when green. Managing these harmful vines is a significant challenge and an important one if native biodiversity is to be conserved. Manual clearing has been applied resulting in the suppression of vine growth, but is not feasible for application over large areas. A management strategy involving chemical and manual removal followed by land rehabilitation is being developed for the long term maintenance of these protected areas.

**Key words:** *Merremia eberhardtii*, *Merremia boissiana*, invasive woody vine, biodiversity, Da Nang City

### **INTRODUCTION**

Located in central region of Vietnam, a transition region between climate sub zones, biodiversity of the Da Nang city area is assessed as very high, and is best represented in Ba Na Nui Chua Nature Reserve, Nam Hai Van Special Use Forest and Son Tra Nature Reserve. Recently, biodiversity of Da Nang has been severely affected by a range of factors; one of which is environmental weeds.

Since 1999, some thousands of hectares of special use forest in Da Nang City were reported to be severely overgrown by unidentified invasive liana species. The plants have been rapidly spreading across plantation and natural forests. Local researchers from Da Nang Forest Protection Department (FPD) thought that the invading plants were two types of bindweed - *Merremia boissiana* and *Merremia eberhardtii*. The later is considered as the most harmful weed for Da Nang's biodiversity.

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Many studies have been conducted for *M. boissiana*, while biological attributes of *M. eberhardtii* still remain unknown. The reason for this is that *M. boissiana* has been recorded as a dangerous invasive species in southern China. Several studies have revealed the causes of its spread. Eco-physiological research shows that the species is characterized by rapid growth, higher photosynthetic and competition capacity, stronger ability to withstand environmental stresses, and therefore it shows a wide ecological adaptability and is capable of out-competing native taxa. For example, concentrated aqueous extracts of *M. boissiana* could restrain seeds germination of *Brassica parachunensis*, and the bigger the concentration, the stronger the restraint (Zeng et al., 2005). Study on its photosynthetic capacity using gas exchange technique found that the light saturated point and maximal net photosynthetic rate of *M. boissiana* were higher than those of invasive weeds such as *Pueraria lobata* and *Mikania micrantha* (Li et al., 2006). In addition, increasing temperature would cause larger biomass and greater production of *M. boissiana*, resulting in its fast growing and spreading. Thus given climate change predictions one might expect that problems caused by this species will increase in the near future (Zhao et al., 2006).

Since 2000, Da Nang authority has mobilized local efforts and money to chop down, dig up or burn the plant to stop the two species of bindweed from spreading to other areas. However, this method of intense manual control tried on the invader has so far been unsuccessful. This requires a massive amount of manpower, and the overall effect of this remains unclear. Seeking for sustainable methods of management, in 2010 Da Nang authority officially requested the University of Queensland (Australia) to provide technical assistance to deal with these bindweeds. In April 2011, a small team of scientists from the University of Queensland (UQ), led by Professor Steve Adkins conducted a rapid field survey of the *Merremia* species that are invading the natural landscapes around Da Nang City, Vietnam. The aims of the survey were to: (i) identify and confirm taxonomy of the species of *Merremia* invading the landscapes around Da Nang; (ii) assess the extent of the *Merremia* problem in these landscapes; (iii) undertake biological and ecological observations on these *Merremia* species and (iv) to consult with local experts to obtain further information on these species.

## **MATERIALS AND METHODS**

### **Study areas**

The survey was conducted in three protected areas as summarized in Table-1.

**Table-1. Locations of the three surveyed sites**

No.	Name of protected areas	Coordinates	Districts
1	Son Tra nature reserve	16 <sup>0</sup> 06' - 16 <sup>0</sup> 09'N 108 <sup>0</sup> 13' - 108 <sup>0</sup> 21'E	Son Tra
2	Nam Hai Van special use forest	16 <sup>0</sup> 10'N - 108 <sup>0</sup> 05'E	Hoa Vang and Lien Chieu
3	Ba Na Nui Chua nature reserve	15 <sup>0</sup> 57' - 16 <sup>0</sup> 08'N 107 <sup>0</sup> 49' - 108 <sup>0</sup> 04'E	Hoa Vang

### **Son Tra Nature Reserve**

Son Tra Nature Reserve covers an area of 4,439 ha, including 4,180 ha of natural forest and plantation forest. The Nature Reserve covers a rocky peninsula, situated to the north-east of Da Nang city. Typical vegetation of the Nature Reserve is primary forest, dominated by timber plants of the *Fagaceae*, *Dipterocarpaceae*, *Anacardiaceae*, *Moraceae* and *Sapindaceae* families. Other habitats present at Son Tra include scrub, grassland and plantation forest. Flora of the Nature Reserve consists of 985 plant species, of which 22 species was listed in the Viet Nam red book. Regarding fauna, 287 animal species were listed in the fauna of the Nature Reserve including 36 mammal species, 106 species of bird, 23 reptiles species and 113 species of insect. Among these species, 15 rare species were found (Dinh T.P.A, 1997).

### **Ba Na Nui Chua Nature Reserve**

The Nature Reserve has a total area of 8,838 ha. It is centred on Mount Ba Na, a 1,487 metre-high mountain on the border between Da Nang city and Quang Nam province. The main natural vegetation types present at Ba Na-Nui Chua Nature Reserve are lowland evergreen forest and lower montane evergreen forest. The first forest type is characterised by the presence of tree species in the *Dipterocarpaceae*, while the later forest type is dominated by species in the *Lauraceae*, *Fagaceae* and *Podocarpaceae* families. Areas which have been cleared of forest support scrub or Eucalyptus plantations. The summit of Mount Ba Na was cleared of forest by the use of herbicides during the Second Indochina War and now supports grassland (Hill et al. 1996). Flora of Ba Na NR comprises 793 species, belonging to 487 genera and 134 families. 19 species were listed in the Red book of Vietnam (Nguyen N.T, 2003). Regarding fauna, Ba Na Nui Chua has 256 species, of which 61 species of 26 families belongs to mammal order. 179 bird species (Da Nang statistic yearbook 2009) and 17 reptile species (8 families).

### **Nam Hai Van Special Use forest**

Nam Hai Van is included on the 2010 list as a 10,850 ha cultural and historical site, including 3,550 ha of forest (FPD 1998).

The original vegetation of Nam Hai Van would have been lowland evergreen forest below 1,000 m and lower montane evergreen forest above this elevation. However, the natural forest has been extensively cleared by wartime spraying of defoliants, timber extraction, clearance for agriculture and fire. Nam Hai Van lies at the southern extent of the Annamese Lowlands Endemic Bird Area. However, although the avifauna of neighboring Bach Ma National Park has been well studied; less information is available about Nam Hai Van.

## METHODS

An initial search and review of the scientific literature regarding *Merremia boisi* and *Merremia eberhardtii* were done in order to collect information related to biological profiles of these two species.

With the purpose of consultation, collection and collation of relevant information, a seminar was conducted in Da Nang City. Participants included local experts, leaders of relevant departments such as Environment and Natural Resources, Agriculture and Rural Development, and Forest Protection Department. General background of environmental weeds and review of *Merremia* species were presented at the seminar. Information essential to identify and describe plant communities of the study areas such as physiognomy, floristic composition, vegetation profile, environmental and physical parameters were collected.

A two-day field study was carried out to take appropriate observations, photos and samples. Samples of the two species were collected to consult with eminent botanists at the Hochiminh University of Science to confirm the taxonomy the two species. A flora sheet including species occurrence was used to record the broad floristics.

## RESULTS AND DISCUSSIONS

### The invading species and invasion situation in Da Nang

The survey confirmed that the *Merremia* species invading Da Nang city are *M. eberhardtii* and *M. boisi*. Comparison of collected samples and specimens at the National Herbarium (VRM- under management of Institute of Tropical Biology) found that the most serious invasive *Merremia* at the Son Tra nature reserve and the Nam Hai Van special use forest is *M. eberhardtii* (Figure 1), having a white flower. This name was also suggested by Forest Protection Department of Da Nang and Nguyen P.N and Le C. K. from Hochiminh University of Science (Personal communication). The species also is recorded in Thua Thien Hue province (Bach Ma National Park, Truoi Lake and Lang Co).

At Ba Na Nui Chua nature reserve, the invasive *Merremia* species had a yellow flower, and was identified as *M. boisi* (Figure

2). This species has been reported to be a common invasive species in southern China. Serious damage has occurred to the middle and lower altitudinal regions of the secondary and artificial secondary forests of Hainan Island. Additional, but less intense damage has been reported from Yunnan and Guangxi Provinces in China (Wu *et al.* 2007). The cause of this recent problem in China has been attributed to climate change in this region of China primarily do to an increasing ambient temperature. According to Chinese scientists, *M. boissiana* has three possible centres of origin: firstly in Hainan Island, China, or secondly in Kalimantan Island (Malaysian Sarawak and Eastern Indonesian Kalimantan), or thirdly in the Sa Pa (Lao Cai Province), Tien-Yen (Quang Ninh Province) regions of Vietnam that border the Mekong region of Laos and Guangxi Province, China. Guangzhou. China is now rapidly becoming a new centre of distribution (Wang *et al.* 2005).



**Figure 1. *M. eberhardtii* (Photo: Forest Protection Department of Da Nang).**

About 920 ha of the special use forest in the Son Tra Nature Reserve and 1,100 ha of the protected forest at Nam Hai Van Pass, Da Nang City are severely affected by *M. eberhardtii* (Figure 3 and 4). This invasive woody vine has been rapidly spreading across these protected areas since 1999 (FPD of Da Nang). In nearby Ba Na Nui Chua Nature Reserve, nearly 300 ha of forest are affected by *M.*

*boisiana* (Figure 5). In all locations these woody vines act primarily by climbing up and covering the forest canopy, killing the trees and plants below by preventing them from obtaining sunlight. The presence of these invasive plant species also heightens the risk of forest fires as their large, thick leaves catch fire easily, even when green.



**Figure 2. *M. boisiana* (Photo: Forest Protection Department of Da Nang)**

### **Ecological observations**

In the areas where *Merremia* plants have been cleared, many environmental weeds are now present and include: *Vitis pentagona*, *Lantana camara*, *Eupatorium odoratum*, *Bauhinia bracteata* and *Calotropis gigantea* (Figure 6). Therefore, attention needs to be paid to the nature of the vegetation regeneration that occurs after the clearing of the *Merremia* species at the Son Tra Nature Reserve.

Clearing the *Merremia* vines creates a favourable environment for the regeneration of the *Merremia* species from seed in the seed bank as well as many other environmental weeds that have dispersed their seeds to this area. For example, a wild grape species (*Vitis pentagona*) has become well established in this area and is now becoming a new dominant weed species. In addition, it was also noted that seedling regeneration of *M. boisiana* (but not *M. eberhardtii*) was

occurring in this area. Seed banks of *Merremia* species, therefore, should be studied carefully to understand the threat of re-introduction in the cleared areas.



**Figure 3. *M. eberhardtii* covering plants in Son Tra Nature Reserve**



**Figure 4. *M. eberhardtii* climbing the canopy of 20 year old pine trees in the special use forest of Nam Hai Van**



**Figure 5. *M. boisiana* covering plants in Ba Na –Nui Chua Nature Reserve**



**Figure 6. Vegetation regeneration after clearing *Merremia* plants**

Other co-occurring species recorded in the forest areas were: *Grewia asiatica*, *Claoxylon indicum*, *Mallotus hookerianus*, *Ficus hispida*, *Sterculia lanceolate*, *Macaranga denticulata*, *Trema cannabina*, *Millettia dielsiana*, *Pueraria lobata*, *Dalbergia hancei*, *Abrus precatorius*, *Albizia corniculata*, *Lygodium japonicum*, and *Embelia laeta*. There is a need to study the reproductive biology of these co-existing species to understand the effect vegetation clearing has upon these species.

A native timber species, *Hopea odorata*, is being replanted into the area after the vines are cleared. However, the growth of this species is very slow due to poor soil nutrient content and being



smothered by weeds. Therefore, the Management Board of the nature reserves should consider growing other, more faster-growing native shrubs or small trees that can create a ground cover more rapidly, preventing the re-invasion of *Merremia* species, then consider planting the more valuable native tree species at a later date to form a natural forest canopy.



**Figure 7. Regeneration of *Merremia* species from seed (believed to be *M. boisiana*).**



**Figure 8. Rhizome system of *M. eberhardtii***

According to Mr. Ho Ngoc Luong, vice head of Lien Chieu district Forest Protection Department, local people have started to use leaves of *M. eberhardtii* to feed their pigs. It is also considered to be a suitable food source for raising wild pigs. This information may be useful in initiating a study looking into the commercial use of this plant species.

### **Management measures**

Managing these invasive vines is a significant challenge and an important one if the native biodiversity of the region is to be conserved. Manual clearing has been applied resulting in the suppression of vine growth, but this is not feasible for application over large areas. A management strategy involving chemical and manual removal, followed by land rehabilitation needs to be developed for the long term maintenance of these protected areas.

- The efforts of the People's Committee of Da Nang and other Departments concerned in trying to control these invasive plants by manual methods, is to be commended. This method is the most relevant one when no specific information is available on the ecology of the invasive species and information on how other related weedy vines are being successfully managed in other countries.



- Manual clearing needs to be applied until studies can be completed which propose efficient alternative methods for the management of these woody vines. Within the current management practice, the body of the vines needs to be collected and isolated from the ground, to desiccate and then to be burnt. This is a necessary step as decaying vines on the ground surface are likely to release allelopathic substances that may inhibit the germination of native plants.
- In the areas where the extensive growth of *M. eberhardtii* has completely inhibited the growth and development of all other species, chemical control might be used to kill this white-flower species. This method is unlikely to affect the other plant species in the community, but special attention may need to be paid to the effects of the herbicides on the soil characteristics. For the yellow-flowered *M. boissiana* species, the using of herbicides will need to be very carefully applied so not to affect the co-occurring native species in the community.
- *M. eberhardtii* will be extremely difficult to control, as the extensive underground root and rhizome system (Figure 8) will be difficult to remove manually or to be killed with herbicides. However, it will be achieved with persistent management, over a number of years, and if the vine has a limited seed bank with low or no seed dormancy to cause re-infestation.
- Population densities of the vine could be reduced by up to 95% after 3 years of persistent control, with root and rhizome density reduced to less than 1% of the pre-control density after 5 years of control. Furthermore, the recovery of host trees following such control could be fairly rapid if dead vine material is rapidly removed and destroyed.
- Effective control will only be achieved with prolonged effort, both involving manual as well as chemical approaches, coordinated into a sound plan of management.

## RECOMMENDATIONS

To expedite the process of management of these woody vine species, there is a need to undertake research. This will need to be undertaken in two phases before any appropriate long term management strategies can be developed that will have resilience under a changing climate.

The main objectives of this short-term research would be: (i) Using two kinds of herbicide trials on small areas of infestation (contact herbicides that target leaves and translocated herbicides attacking the leaves and the underground stem system). Consulting with experts in weed management in Australia and others countries in

Asia-Pacific region will generate a list of recommended chemicals that can be safely used to eradicate the plant as well as preferred methods of application. Priority will be given to approaches that kill both stems and roots; (ii) Establishing sample plots where the vines and also secondary weeds are removed in order to monitor the regeneration and the successional change in the plant community. There will be a need to conduct soil seed bank studies to find out what weed seeds are present and what native plant seeds are present and ready to restore the community to the way it was before invasion and; (iii) Conducting a survey of the native flora to look for suitable species for planting in the area when the weeds are removed.

Longer term research would focus on developing a sustainable, long-term management strategy to deal with these woody vines. To do this the following activities would need to be undertaken: (i) Conduct a comprehensive investigation across all of Da Nang and Thua Thien Hue Province to clearly document the distribution of these two invasive species so that the authorities can launch a timely campaign to manage it out over the wider area; (ii) Look at the possibility of using biological control agents to manage these woody vine species. This study will aim to introduce natural enemies from the regions where the vine is native after conducting suitability trial experiments; (iii) Studying physiological and ecological attributes of these species in order to find out the important factors that enable them to become successful invasive species in the area, and to identify weaknesses in their life cycle that may be exploited to obtain better management. The final goal would be to develop an integrated management program for these species and would be robust and effective under a changing climate.

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