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Non-native Species in Floodplain Secondary Forests in Peninsular Malaysia

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Abstract

There is an increasing concern of alien species invading our tropical ecosystems because anthropogenic land use can create conditions in which non-native species thrive. This study is an assessment of bioinvasion using a quantitative survey of non-native plant species in floodplain secondary forests in Peninsular Malaysia. The study area is known to have a long cultivation and settlement history that provides ample time for non-native species introduction. The survey results showed that introduced species constituted 23% of all the identified species, with seven species unique to riparian forest strips and eleven species unique to abandoned paddy fields and the remaining five species being shared between the two secondary forest types. There existed some habitat preferences amongst the species implying both secondary forests were potentially susceptible to bioinvasion. Fourteen species are also invasive elsewhere (PIER invasives) whereas fifteen species have acquired local uses such for traditional medicine and food products. The presence of these non-native species could alter native plant succession trajectory, and eventually leads to native species impoverishment if the exotics managed to outcompete the native species. As such, the findings of this study have a far-reaching application for the national biodiversity conservation efforts because it provides the required information on bioinvasion.

Keywords: non-native species; ecological invasion; Peninsular Malaysia

1. Introduction

It is widely known that humans are efficient dispersers of non-native species (also known as alien or exotic species) for agricultural and decorative purposes. Unintentional introductions are not uncommon, some as prosaic as the seeds of weeds getting mixed in soils and transported into a foreign place (Elton, 1958; Mack, 1992). While the growth of non-native agricultural species are encouraged, the other aliens are considered ecological villains because some possess several competitive advantages including the absence of natural enemies (predators, pests, competitors) and/or the ability to fix nitrogen, and thus becoming too successful in the new environment and flourishing at the expense of certain native species (Elton, 1958; Lorence and Sussman, 1986; Loope, 1992; Mack, 1992; D'Antonio *et al.*, 1999). The global concern for biological invasion, which started in North America and Europe, stemmed from the population epidemics and pest outbreaks of non-native species (Elton, 1958). It is now common for conservationists to use the invasiveness of these alien species as a reason for eradicating them from an area (Mack, 1992; Cronk and Fuller, 1995; Daehler, 1998).

Current research on non-native species ranges from cataloging non-native species to understanding the effects of climate change on biological invasion (Milbau and Stout, 2008). In Malaysia the concerns for non-native species are derived mainly from the economic costs of non-native weed infestation in water bodies, plantations and paddy fields as biological control in the country only started in 1970s (Ismail and Sivapragasam, 2001; Othman and Abu Hashim, 2003). Thus far the reported alien invasive plants are not many and are mostly identified as agricultural weeds (Ismail and Sivapragasam, 2001; Othman and Abu Hashim, 2003). Moreover, very little work has been carried out to investigate the level of exotic plant invasion of the Malaysian flora (Azmi, 2002; Othman and Abu Hashim, 2003), although opportunistic records of the presence of non-native species in forest reserves, forest fragments, secondary forests and/or human settlements in the peninsula began much earlier (Burkill, 1935; Sanger-Davies, 1935; Henderson, 1954; Corner, 1940; 1978; Wyatt-Smith, 1949). Only one study to evaluate non-native species invasion had been conducted in the primary forests of Peninsular Malaysia, i.e. *Clidemia hirta* invasion in Pasoh Forest Reserve (Peters, 2001) although *Clidemia hirta* has been considered as weed

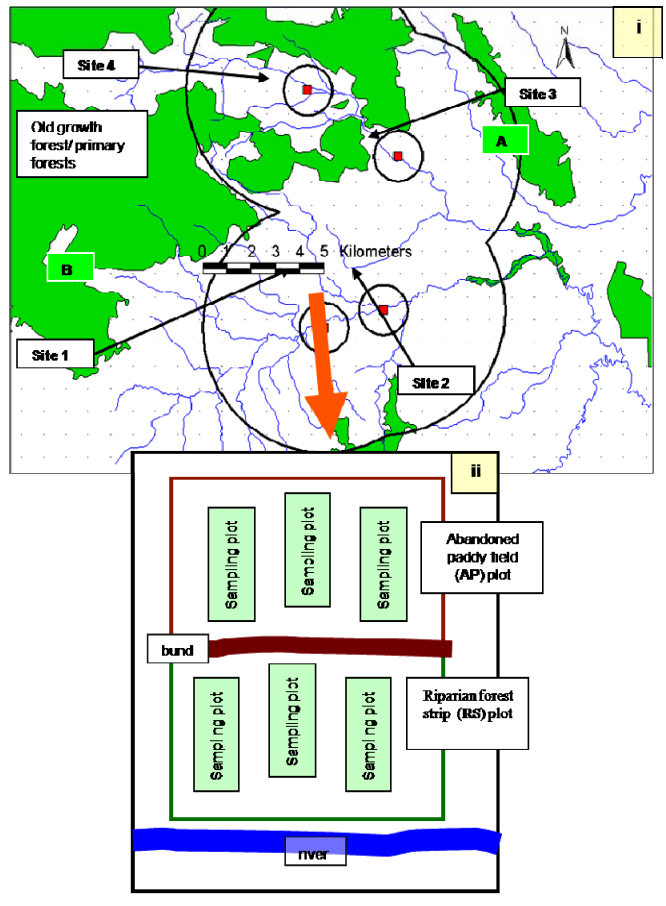

Figure 1. Top figure (i) shows the geographical locations of the four study sites. Bottom figure (ii) shows the schematic representation of the sampling plots in the abandoned paddy fields and the riparian forest strips at each site. See text for details.

in this country since the early part of last century (Corner, 1949; Burkill, 1935; Azmi, 2002). This study therefore aims to investigate the prevalence of non-native species in secondary forests near agricultural areas in Peninsular Malaysia. Given the long history of human settlement and land use, it is expected that a high percentage of non-native species would be found in the secondary forests.

2. Methods

2.1. Study area

This study was conducted in the narrow inland floodplain of Peninsular Malaysia (2˚50´N, 102˚30´E). Traditional household paddy fields were established there by the 17th century, i.e. long enough to be termed 'prolonged cultivation', but were abandoned in the mid-1980s (Hashim, 2006). Vegetation sampling was conducted in two types of secondary forests located near agricultural areas and human settlements (Fig. 1). The two secondary forest types were abandoned household paddy fields of about 18 years old and riparian forest strips of more than 30 years old. All sites were located along the tributaries of River Muar, and at least 1 km away from old growth/ primary forests at elevations below 100 m a.s.l. The area receives high annual rainfall, and monthly rainfall of 7-22 cm, while the daily temperature is like most lowland places in Malaysia with a monthly range of 25.6˚C to 27.8˚C (Ooi, 1976).

2.1. Vegetation survey

A total of twelve 20 m x 5 m sampling plots were set up in four abandoned paddy field (AP) sites, and another twelve plots in the adjacent riparian forest strip (RS) sites (Fig. 1). Vegetation sampling took place during January to April 2003. In this survey, four different life forms were sampled as follows:

a. Bamboos.
b. Herbs (climbers and non-climbers, e.g. creepers and grasses).
c. Trees and Shrubs.
d. Arborescent (standing) palms.

All plant species present in the sampling plots were identified to the lowest possible taxonomic level and the following publications were useful references:

i. Wayside Trees of Malaya (Corner, 1940; 1988; Two Volumes).

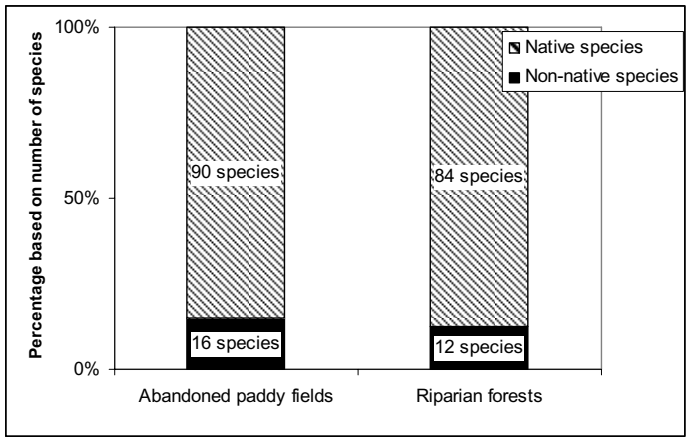

Figure 2. The composition of non-native species in the two secondary forest types in this study

ii. Tree Flora of Malaya (Volumes 1 & 2, edited by Whitmore, 1983; Volumes 3 & 4, edited by Ng, 1989).
iii. Ferns of Malaysia in Colour (Piggott, 1988).
iv. Orders and Families of Malayan Seed Plants (Keng, 1969).
v. Malayan Wild Flowers (Henderson, 1954).
vi. The Flora of the Malay Peninsula (Ridley, 1923).
vii. The Bamboos of Peninsular Malaysia (Wong, 1995).
viii. **Tumbuhan Ubatan Malaysia** [Medicinal Plants of Malaysia] (edited by Mat-Salleh *et al.*, 2002).
ix. Palms of Malaya (Whitmore, 1973).
x. **Palma Pilihan Untuk Seni Taman** [Selected Palms for Landscaping] (Saidin, 1997).
xi. A Dictionary of The Economic Products of the Malay Peninsula (Burkill, 1935).

Information on the native distribution of an identified species was scoured from various sources including the Internet. Internet sources include the Hawaiian Ecosystems at Risk Project (HEAR), the Prospective Invasive Species for Pacific Islands (PIER) and the Maui Invasive Species Committee (MISC) websites (http://www.hear.org; http://www.hear.org/pier/prospective.htm; http://www.hear.org/misc/).

3. Results and Discussion

A total of 1109 stems of trees, shrubs and arborescent palms were sampled in this study of which 643 (58%) stems were sampled in the abandoned paddy fields (AP) plots and 466 (42%) stems in the riparian forests (RS) plots. In terms of species richness, the total number of recorded species of all life forms (bamboos, herbs, shrubs, trees and palms) was 135 of which 99 species could be identified to the species level. Introduced species constituted 23% of total identified species (23 species/99 identified species), or 16 non-native species/90 total known species in the AP plots and 12 non-native species/ 84 total known species in the RS plots (Fig. 2). Seven species were unique to the older riparian forests and eleven species unique to the younger abandoned paddy field forests whilst the remaining five were shared between the two forest types (Table 1). If all of the un-identified species were native, then introduced species constituted 17% of the total 133 species, and if instead all the un-identified species were introduced species, the percentage would go up to 43%. Additionally, four non-native species (*Arenga pinnata*, *Asystasia coromandeliana*, *Clidemia hirta* and *Mitracarpus hirtus*) had a wide local distribution, i.e. these species were found in more than ten sampling plots (Table 1). Only four of the non-native species were trees, another three were standing palms and the remaining sixteen species were non-trees, mostly herbaceous creepers (Table 2).

Fourteen out of 23 identified non-native species had acquired local uses (Table 3). The highest use category was non-foodstuff (7 species) whereas a lower number of species belonged to the medicinal or foodstuff categories (6 species, respectively). This is not surprising because many introduced species were brought into the Malay peninsula as plantation crops (e.g. cocoa and oil palm), or as shade trees (e.g. *Gliricidia sepium* as hedge plants in cocoa plantations), whilst others, such as the aroid *Dieffenbachia seguine* and the shrubby *Lantana camara,* were intentionally brought into the areas for ornamental purposes (Burkill, 1935; Corner, 1988). Moreover, non-native species such the tree bamboo, *Bambusa vulgaris*, sago, areca and *Arenga pinnata*, have been commonly planted in the villages for use since the traditional period. Unlike the relatively recent introduction of cocoa, oil palm and *G. sepium*, four other species (sago, areca, *Arenga pinnata* and the tree bamboo) are all believed to have been introduced into the peninsula many centuries ago

Table 1. No. of sampling plots for each forest type and the total number of plots in which each non-native species was recorded.

Species	No. of AP sampling plots	No. of RS sampling plots	Total plots	≥ 10 plots
Areca catechu	0	1	1	no
Arenga pinnata	5	11	16	yes
Asystasia coromandeliana	8	7	15	yes
Bambusa vulgaris	0	5	5	No
Chromolaena odorata	6	0	6	No
Clidemia hirta	11	4	15	yes
Cyathula prostrata	0	1	1	no
Dieffenbachia seguine	0	1	1	no
Elaeis guineensis	0	1	1	no
Elephantopus scaber	1	0	1	no
Gliricidia sepium	1	0	1	no
Hyptis capitata	1	0	1	no
Lantana camara	1	0	1	no
Metroxylon sagu	0	2	2	no
Mikania micrantha	6	1	7	no
Mimosa pudica	4	0	4	no
Mitracarpus hirtus	11	0	11	yes
Muntingia calabura	0	1	1	no
Oxalis barrelieri	1	0	1	no
Paspalum conjugatum	4	0	4	no
Psidium guajava	5	0	5	no
Stachytarpheta cayennensis	5	0	5	no
Theobroma cacao	2	4	6	no

and are now considered naturalized. Others were likely to have been introduced into Malaysia unintentionally and so it is interesting that one non-native weed species, the herbaceous *Elephantopus scaber*, was used by the villagers for its medicinal properties. Other non-native species found in the secondary forests were likely garden-escapes because there are many examples of non-natives species escaping from botanical gardens as well as from household gardens (Henderson, 1954; Corner, 1988; Cronk and Fuller, 1995). The two non-native agricultural crops, *Theobroma cacao* and *Elaeis guineensis,* might have become regular escapes from small-holding plantations.

Out of the 23 introduced species in this study, 14 species (or 61%), including *Clidemia hirta, Chromolaena odorata, Lantana camara, Mikania micrantha,* have been found to be invasive in the Pacific islands like Hawaii (PIER; Table 2) but only five non-native species from this study (*Chromolaena odorata, micrantha, Mimosa pudica, Asystasia coromandeliana* and *Clidemia hirta)* have been recognised as major invasive species in Malaysia thus far (Burkill, 1935; Ismail and Sivapragasam, 2001; Othman and Abu Hashim, 2003). This could be due to poor monitoring and/or ecological reason. Unlike the evolutionarily isolated Pacific islands (PIER), the Malay peninsula might not be as naturally sensitive to invasion due to high levels of biodiversity. Nonetheless, the high levels of anthropogenic disturbance as well as intentional and unintentional introduction might have increased the invasion potential of certain non-native species (Hobbs and Huenneke, 1992; Loope, 1992; Bazzaz, 1996, Peters, 2001). For this reason, it is worthwhile to monitor and assess and the levels of non-native species invasion in secondary and primary forests in the peninsula. For forests that are especially exposed to anthropogenic disturbance, the presence of non-native species could alter the succession trajectory, and

Table 2. The list of non-native species identified in this study. AP = abandoned paddy field plot; RS = riparian forest strip plot. PIER = Prospective Invasive Species for Pacific Islands. Those highlighted in light yellow are agricultural species.

Species	Life form	Origin	PIER Invasive
Arenga pinnata	Palm	Assam and Burma	N/A
Chromolaena odorata	Herb	South America	Yes
Clidemia hirta[2]	Herb	South America	Yes
Cyathula prostrata	Herb	South America	No
Dieffenbachia seguine	Herb	South America	Yes
Elaeis guineensis	Palm	South America	No
Elephantopus scaber	Herb	South America	No
Gliricidia sepium	Tree	South America	Yes
Hyptis capitata	Herb	South America	Yes
Lantana camara	Herb	South America	Yes
Mikania micrantha	Herbaceous climber	South America	Yes
Mimosa pudica	Herb	South America	Yes
Muntingia calabura	Tree	South America	Yes
Oxalis barrelieri	Herb	South America	No
Psidium guajava	Tree	South America	Yes
Theobroma cacao	Tree	South America	No
Stachytarpheta cayennensis	Herb	South America	Yes
Mitracarpus hirtus[1]	Herb	South America	No
Asystasia coromandeliana	Herb	Africa	Yes
Paspalum conjugatum	Grass	South America	Yes
Metroxylon sagu	Palm	Mollucas, West Irian	No
Areca catechu	Palm	Northern Borneo, Philippines, Sulawesi	No
Bambusa vulgaris	Tree bamboo	Asian origin	Yes

eventually leads to native species impoverishment if these exotics managed to outcompete the native species. It remains to be seen what kinds of forest composition will result several decades on, when the direct effects of human activities may also intensify, and when these sites may be affected by other edge-effects such as surface runoffs from adjacent sites that are under intensive agriculture or human habitation.

4. Conclusions

The percentage of non-native species in the two types of secondary forests in the inland floodplain of Peninsular Malaysia may be as low as 23 % of the total identified species but the potential of invasion of these species remains unknown. More studies are therefore needed to identify the pathways of introduction and to evaluate the invasiveness of non-native species because the floodplain secondary forests, including the narrow strips of riparian vegetation, harbour local species important to the country's biodiversity and/or having special conservation values (DID, 2005; WWF-Malaysia, 2009) that are threatened by the non-natives. Moreover, this study should be replicated in other forest types so as to expand the database of the presence and diversity of non-native species that can be used as forest health indicators.

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Table 3. Use categories for 23 identified non-native species in this study.

Species	Life form	Origin	PIER Invasive
Species	Edible parts	Medicinal	Other Uses
Areca catechu	no	yes	ceremonial
Arenga pinnata	yes	no	no
Asystasia coromandeliana	no	no	no
Bambusa vulgaris	shoots	no	implements
Chromolaena odorata	no	yes	no
Clidemia hirta	no	no	no
Cyathula prostrata	no	no	no
Dieffenbachia seguine	no	no	ornamental
Elaeis guineensis	fruits	no	fish bait/ cash crop
Elephantopus scaber	no	yes	no
Gliricidia sepium	no	no	no
Hyptis capitata	no	no	no
Lantana camara	no	yes	no
Metroxylon sagu	sago	no	poultry feed
Mikania micrantha	no	no	no
Mimosa pudica	no	yes	no
Mitracarpus hirtus	no	no	no
Muntingia calabura	fruits	no	no
Oxalis barrelieri	no	no	no
Paspalum conjugatum	no	no	grazing grass
Psidium guajava	fruits	yes	no
Stachytarpheta cayennensis	no	yes	no
Theobroma cacao	no	no	cash crop

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