Managing alien invasive species in Malaysia

Yahaya bin Hussain[1] and Sivapragasam Annamalai[2]

[1] Rice & Industrial Crops Research Center, Telong,
16310 Bachok, Kelantan, Malaysia

[2] Rice & Industrial Crops Research Center,
P.O. Box 12301, Kuala Lumpur, Malaysia

Email: hyahaya@mardi.my; sivasam@mardi.my

Abstract

The Malaysian experiences with invasives alien insect pests are described. In addition to the discussion on the current situation of invasive alien species problems which include those of cocoa pod borer, the khapra beetle, golden apple snail and diamondback moth, management of three recent invasive insect pests on horticultural crops were elucidated as examples. These were the beet armyworm, *Spodoptera exigua*; leafminers, *Liriomyza sativae, Chromatomyia horticola* and *Liriomyza huidobrensis* and the whiteflies complex that include the sweet potato whitefly*, Bemisia tabaci*, the greenhouse whitefly, *Trialeurodes vaporariorum* and the spiraling whitefly, *Aleurodicus dispersus*. Suggestions were provided for further strengthening the capability of the country in dealing with the invasive pest problem in the future.

Introduction

Invasive alien species (IAS) was defined by The Convention on Biological Diversity (CBD) as a species, subspecies or lower taxon (includes any of its part that might survive and reproduce) introduced outside its natural past or present distribution (Roger, 2003). In the context of CBD, IAS is one that threatens biological diversity but in the broader context it is one that has negative impacts in any area such as agriculture, human development, human health as well as biodiversity (Roger, 2003). The problem of insect pests, whether endemic or exotic, has always been a major concern in agriculture. The problem of alien insect pest species has become more significance due to the global interest in biodiversity. The driving force behind this problem is the apparent breakdown of bio-geographical borders due to increasing international trade and globalization exacerbated by the modern modes of transportation that enhance the probability of biological invasions.

According to Kiritani (1998), the biological process of colonization or invasion by alien organisms can be divided into four steps: (i) Introduction, (ii) Establishment, (iii) Spread, and (iv) Naturalization. The introduction of invasives can be through a number of ways: (i) Long distance migrations or movements (e.g. the brown planthopper, *Nilaparvata lugens* in rice), (ii) transportation and (iii) Human activities. With increased international travel, the movement and incidences of exotic species had certainly increased in both number and variety. Agricultural products, especially fresh produce such as vegetables, ornamentals, stored grains and timber are particularly concerned. The rates of successful introduction, colonization and subsequent naturalization of an invasive species in a new habitat are fortunately, incredibly low. Environmental sieves and dispersal constraints, natural disasters and human interventions influence the outcome of the establishment of IAS. Studies in Britain, for examples showed that only 0.53% of the 220,000 imported species to Britain became naturalized and not all of them were invasive (Crawley et al., 1996). The low incidences of successful naturalizations are attributed to low base-rates probability of invasions (Williamson, 1998).

Malaysia's encounter with invasive species

Several serious invasive alien pests had already reached the Malaysia and collectively impacted on its agricultural landscape and economy. Examples of such pests are shown in Table 1. Malaysia also keeps watch on several other alien pests which are yet to be detected but are considered to be a threat to economic crops. These invasive pests include thrips species (*Scirtothrips dorsalis, Chaetanaphothrips signipennis* and *Frankliniella bispinosa*) on vegetables and fruits, the Mediterranean fruit fly (*Ceratitis capitata*) and the San Jose Scale (*Quadraspidiotus perniciosus*) on citrus, the larger grain borer (*Prostephanus truncatus*) of stored products and the palm weevil (*Rhynchoporus palmarum*) of oil palm (Asna et al., 2001).

Malaysia has also been the source of IAS based on interceptions by importing countries. Some of the recent interceptions were: (i) Aquatic plants infested with the whitefly, *Bemisi tabaci* and by the snail, *Achatina fulica* by France and Japan, respectively; (ii) Fresh chrysanthemums infested with thrips, *Frankliniella occidentalis* to Taiwan; and (iii) Carambola fruits infested with fruit flies to France (Sivapragasam, 2005).

Table 1: Examples of important invasive pests detected in Malaysia (Asna et al., 2001)

Crop	Pest species	Year recorded	Country of origin (suspected)
Cocoa	? *Conopomorpha cramerella*	1986	Indonesia
Vegetables	? *Chromatomyia horticola*	1986	Holland
	? *Spodoptera exigua*	1996	Thailand
	? *Trialeurodes vaporariorum*	?	Holland
Cut flowers	? *Liriomyza huidobrensis*	1991	Holland
Turf	? *Nematode, Meloidogyne graminis*	1980	USA
Citrus	? *Nematode, Tylenchlus semipenetrans*	1996	Indonesia
Paddy	? *Golden apple snail, Pomacea canaliculata*	1984	Philippines
	? *Echinochloa crusgalli*	1979	Australia

Management of Invasive Alien Insect Species (IAIS)

Four options or steps for dealing with alien species had been proposed (Wittenberg and Cock, 2001): (1) Prevention; (2) Early detection; (3) Eradication and (4) Control. In Malaysia, the four major programs are implemented by the Department of Agriculture under the Malaysian Plant Quarantine Act 1976 and the Plant Quarantine Regulation 1981 to prevent the entry and spread of alien invasive species are, viz., prevention, detection and monitoring, containment and eradication and control. Prevention and eradication which are the front liners of defense in managing the IAS, seemed to be fraught with difficulties: prevention due to the complexity of the problem facing the front-line quarantine service and its capability to filter the IAS before they enter into the country (see below); and eradication generally due to the exorbitant costs involved. In most cases, the IAS is detected only after they had entered and spread into the country. Thus, the management strategy employed centers around control to minimize further risks.

1. Prevention

Prevention is the first line of defense against any invasive pest. The Malaysian Plant Quarantine Act 1976 and Plant Quarantine Regulation 1981 are

the two laws that aim to prevent the entry and spread of noxious plants and pests of plants that can threaten the agriculture industry. Besides alien invasive pest species, the Quarantine Act also has provision to control outbreaks of endemic pest. In regulating the alien invasive pest species, the Quarantine Regulation has listed 240 species of insects, fungus, viruses and weeds that are prohibited from importation, possession or keeping. This List, which is a dynamic one, is gazetted in the Fourth Schedule of the Regulation. Thus, all goods that harbor pests in the List will be treated or destroyed immediately. Apart from the prevention of entry, the Quarantine Act and the Quarantine Regulation also have provision to contain, eradicate or control of any dangerous pest either foreign or endemic found in the country. This provision has given adequate authority to the Department of Agriculture to call the relevant bodies or agencies to collaborate and enforce any action to eradicate or control this pest. The Department of Agriculture, with 250 enforcement officers stationed in all the 49 entry points, inspects all agricultural goods that are imported into the country. Agriculture products or consignments found infested with live pests are held at a secured area at the port of entry until the pests are identified. Upon confirmation of the quarantine pests, the consignments are either confiscated and destroyed or returned to the exporting country (Mat Hassan et al 2001).

Despite the stringent quarantine protocol, invasive pests still escaped quarantine barriers as evidenced by the number of recent Malaysian interceptions (Table 1). In the year 2000, a total of 580 agricultural consignments with pests were intercepted. However, only 82 species of arthropods belonging to 8 orders and 41 families were identified. Out of this total, three species (*Trogoderma granarium, Ceratitis capitata* and *Diatrea* sp.) were pests gazetted under the present quarantine Act (Wan Normah and Asna, 2001). The recent growth of the highland (temperate) horticultural industry has also been conducive towards the increase in the number of invasive species, particularly greenhouse pests such as whiteflies and leafminers. A similar situation had been reported in other countries such as Japan (Kiritani, 1999). Commercial activities do enhance the transnational spread. For example, Tan and Lim (1985) found that between 18.5 – 38.9% of English cabbage heads imported from Indonesia were infested with insects. The insects recorded were *Plutella xylostella, Crocidolomia binotalis, Heliothis* sp. and the beetle, *Dinoderus minutus*. Besides these insects, aphids, earwigs, slugs, collembolas and earthworms were also found within the cabbage heads.

2. Detection

Early detection of introductions and quick, coordinated response can eradicate or contain alien invasive pest species at much lower cost than long-term control. Apart from inspection at entry points, there is no comprehensive national system that is in place for detecting incipient invasions of alien invasive pest species. However, a limited number of programs are in place for the key commodities of rice, rubber and oil palm. The Pest Surveillance and Forecasting System was set up in 1979 in Peninsular Malaysia by the Department of Agriculture to detect and monitor rice pests particularly naturally invasive pests. The pests and crops are monitored regularly through field scouting, light traps, net traps and mobile nursery. For rubber and oil palm, the Malaysian Rubber Board (MRB) and Malaysian Oil Palm Board (MPOB), respectively, with the assistance of the Department of Agriculture are carrying out the national monitoring survey bi-annually for early detection of dangerous pest of rubber and oil palm. Apart from these measures, the presence of invasive pests are also detected through normal agricultural extension activities and reports of pest incidence by the public. For monitoring, pheromone traps have been used such as the case for the beet armyworm, S*podoptera exigua* and for *T. granarium.*

3. Eradication

In the past, programs were initiated to eradicate dangerous exotic pests and contingency plans were developed after the pests were detected. Two of those involved IAS, viz., the eradication program for Cocoa Pod Borer (CPB) which was concluded to be unsuccessful as the pest had spread beyond control. Subsequently, the CPB was eventually de-gazetted and is currently managed under the integrated pest management approach.

The second eradication program was for the khapra beetle, *Trogoderma granarium*. Unlike the CPB case, which was relatively complicated due to its widespread nature, the Kharpra beetle, which is believed to be endemic to the Indian subcontinent, was successfully eradicated as the beetle was only found in several isolated rice warehouses. Ganapathi et al (1992) provided a model emergency action program which included detection and eradication. The latter entailed: (i) physical destruction of infested plant products, and (ii) chemical via fumigation of products, warehouses or stored rooms with methyl bromide at 80g/cu.m for 48h depending on the temperature or with phosphine at 2g per cu.

m for 3 days. The other chemical approach is by spraying the warehouse and contaminated materials with chemicals insecticides. Storing of the products below 9% moisture content or less was also effective.

Other than these two programs, there had been no other attempts made to eradicate any of the other IAS even though numerous incursions had taken place. The reason for this is due to the fact that many of these pests (e.g. leafminers, whiteflies) were only detected when they were already widespread throughout the country. Thus, eradication was no longer a cost-effective option.

4. Control

When an alien invasive species appears to be permanently established and widespread, the most effective action advocated will be to prevent their spread or lessen their impacts through control measures. The integrated pest management approach involving the suitable combination of cultural, chemical, biological, mechanical and others are recommended. At this stage, pest control is the responsibility of the farmers themselves or individual owners and government agencies provide advisory services and assistance needed to effectively control the pests. The experiences with the diamondback moth, fruitflies, leafminers and whiteflies are the notable examples.

Malaysian experiences with alien invasive species

1. Cocoa pod borer

Cocoa pod borer, *Conopomorpha cramerella* Snellen was first detected in Sabah in August 1980. From the initial infestation area of 4,000 ha, the pest spread to all major cocoa growing area in Sabah and neighboring Sarawak within two and a half years (Ooi et al. 1987). The pest was detected in Peninsular Malaysia in 1986 and was later spread to other major cocoa growing areas. During the initial stage of the invasion, its control depended on heavy use of insecticides but now, a more environmental friendly approaches has been developed to manage its infestation (Azhar and Lim, 1987). However cocoa pod borer remains as the most important insect pest of cocoa in the country with losses of up to 30% not uncommon in badly infested areas.

2. Diamondback moth

Diamondback moth (DBM), Plutella xylostella L. was first recorded in Malaysia in 1925, in Frazer Hill in the state of Perak. It was later found in Cameron Highland in 1934, which was then newly opened for cultivation of temperate crops. By 1941, it had become a major insect pest of crucifers in the Cameron Highland. Diamondback moth is now a major insect pest of cabbage and crucifers both in the highland as well as in the lowland areas. Commercial *Bacillus thuringiensis* products, insect growth regulators and insecticides are now widely used to manage DBM infestation (Sivapragasam et al. 1986; Loke et al., 1992). IPM approaches are also being practiced by farmers growing cabbages and crucifers in the Cameron Highland (Sivapragasam et al. 1986; Loke et al., 1992).

3. Golden apple snail

Golden apple snail, *Pomacea spp*. was first detected in 1991 in fishponds in Selangor (Mat Hassan et al. 2001). The snail was illegally smuggled into the country for commercial rearing purposes. Nationwide survey to detect the presence of the snail showed that the snail was found in isolated areas such as fishponds, unused tin mines, aquariums and in a small rice field in Kedah. Control measures were undertaken to contain and eradicate the snail. The measures were only successful in the detected areas while those that went undetected led to the spread and dispersal of the snail to much wider areas. Currently, the snail was found in all the major granary areas and is estimated to be present in more than 17,000 ha of rice fields (Table 2). Damages caused by the snail can totally devastated the rice crops depending on the size and density of the snails. Golden apple snail is now managed by integrating various control measures including chemical control, cultural control, duck pasturing, mechanical and physical control.

4. Beet armyworm

The beet armyworm, *Spodoptera exigua*, was recently reported invasive pest in Malaysia (Palasubramaniam et al., 2000; Palasubramaniam and Sivapragasam, 2001). It is a sub-tropical and tropical species widespread in many tropical and temperate regions of the world. *S. exigua* has become an important pest of various economic crops in the last ten years in Malaysia and

Table 2. Distribution of rice area infested with Golden Apple Snail in Malaysia

State	Detected	Rice Area Infested (ha)
1. Selangor	Sept. 1991	48
2. Perak	Oct. 1991	10,000
3. Johore	April 1992	0*
4. Kedah	Nov. 1991	1,061
5. Pahang	1997	0*
6. Negeri Sembilan	2001	291
7. Malacca	2001	40
8. Penang	2001	332
9. Kelantan	2002	347
10. Perlis	1992	50
11. Sabah	1992	5,000
12. Sarawak	1998	230
Total		**17,399**

***** Golden apple snails found in non-rice areas only.

has caused extensive damage to crops such as onions, brinjal, legumes and crucifers. Heavy infestations of *S. exigua* may occur suddenly due to migration of large numbers of adults. As for the case in Malaysia, it is interesting to note that prior to the 1996, *S. exigua* was never reported as a pest, unlike its congeneric species *S. litura*. However, rather surprisingly outbreaks of *S. exigua* began emerging in 1996 (Palasubramaniam *et al,* 2000). Migration of adults is a possibility based on the proximity of Malaysia to its neighboring countries such as Thailand, Indonesia, Vietnam and Myanmar where the pest is endemic and prevalent. The other possible reason could be through transnational commercial activities (Ng *et al*., 1999), which happens to be the case with other similar pest species.

S. exigua is currently a major pest to vegetables. It is very difficult to control as it developed resistant to the most insecticides. The invasive nature of *S. exigua* has shifted the focus from the other endemic pests of vegetables. In the lowlands of Malaysia damage assessment results showed that damage by this pest was almost 100 percent in some crops. Almost all types of vegetable crops grown including brassicas (kailan, sawi, cabbage, kang kong), chilli, brinjal, shallot, long beans, and ladies finger were found to be infested with this pest. Chilli and shallot were the most seriously affected crops and losses were significant. A range of insecticides is used to control *S. exigua* (Sivapragasam, 2003).

Natural enemies play a key role in suppressing *S. exigua* populations (Sivapragasam et al., 2001). In Malaysia, two larval parasitoid species had been bred from field-collected samples. They are, viz, the braconid, *Microplitis manilae* and the tachinid, *Peribaea orbata*. The parasitisation levels of these parasitoids, especially *P. orbata*, was as high as 45% in the field.

5. Agromyzid leafminers

Agromyzid leafminers are pests of economic importance on several vegetables and ornamentals both in the temperate and tropical regions (Spencer, 1973). In Malaysia, the predominant species found infesting vegetables such as sugarpeas and crucifers prior to the 1990s were *Chromatomyia (Phytomyza) horticola* in the highlands and *Liriomyza brassicae* in the lowlands (Ooi, 1979; Sivapragasam et al, 1992). However, in the mid 90s, various other species of *Liriomyza* such as *L. huidobrensis* in the highlands and *L. sativae* in the lowlands were reported (Sivapragasam and Syed, 1999). It is believed that the introductions of temperate cut flower planting materials from Europe could have introduced the leaf miners into Cameron Highlands (Myint, 1997). This situation is quite similar to other countries like Japan where the distribution of leafminers has been largely attributed to the failure of quarantine procedures to detect (for example misidentification) and prevent its entry into the country.

Leafminers are major pests of vegetables and ornamental plants in Cameron Highlands. Yield losses up to 30% were reported on most vegetables crops such as sugar peas, tomatoes, Chinese cabbage, capsicum and french beans if no control measures were undertaken. On chrysanthemums, farmers also reported losses up to 50% due to the leaf miner infestation, particularly by *C. horticola* (Sivapragasam and Syed, 1999). About 17% of the farmers had abandoned vegetable cultivation due to problems of invasive pests.

Insecticides are generally used to control outbreaks followed by use of yellow sticky traps. There has also been attempts to use neem, *Azadirachta indica* (Heng et al., 1994). Under natural conditions, leafminers are attacked by a suite of parasitoids (Myint, 1977; Sivapragasam and Syed, 1999; Sivapragasam et al., 1995a; Sivapragasam et al., 1999a). However, the non-specificity of these parasitoids precludes them as effective biological control agents in the conventional sense. The integrated pest management approach is currently used to manage leafminers in both sugar peas (Sivapragasam et al., 1995b; and Myint, 1997) and in chryanthemums (Sivapragasam et al., 1999b).

6. Whiteflies

Two species of whiteflies were recently found in vegetables in Malaysia. The species found in the lowlands is the sweet potato whitefly, *Bemisia tabaci* (Gennadius) and that in the highlands is the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). It was probably a recent introduction from Europe through importation of ornamentals planting materials (Syed et al, 2000). Another species of whitefly, the spiraling whitefly, *Aleurodicus dispersus* (Rusell) is endemic and found on several ornamental and fruit crops.

Recently the whitefly infestation was serious particularly on tomato, bell pepper and coyote and crops losses up to 50% has been reported. A high degree of insecticide resistance has already developed within many field populations of *B. tabaci* associated with agricultural crops (Martin, 1999). The problem is further compounded by the ability of *B. tabaci* to transmit 60 different types of plant geminiviruses (Syed et al., 2000) and the presence of a new strain of *B. tabaci*, i.e. the B strain which has spread to most parts of the world. Bellows et al (1994) described this strain as a new species, *B. argentifolii* which is morphological similar to *B. tabaci*. To date, in Malaysia, 21 different biotypes of B. tabaci had been observed based on allozyme patterns. The Malaysian population belongs to the Asia 2a group which has also been found in Indonesia, Sri Lanka, North India, Thailand and Bangladesh (Sivapragasam, 2003).

The main method of control is with the use of systemic pesticides, but there are already problems of efficacy. A few predators have been recorded (Syed et al., 2000), viz., a mired bug, *Macrolophus* sp, the green lace wing *Chrysopa* sp. and a coccinellid, *Delphastus* sp. The parasitoid, *Encarsia* sp was recovered from a few field specimens. Currently, the IPM approach is been investigated.

Conclusion

Based on the evidence to date, there are many gaps and needs in the current management strategy against invasives. There are indeed many areas that need to be strengthened to effectively manage the problem. Against the backdrop of resource limitations, some of the urgent areas that need to be pursued in future are as follows:

1. Review and update existing list (Fourth Schedule) of prohibited species with proper pest risk analysis (PRA)
2. Review, update and amend the existing sanitary and phytosanitary

measures

3. Build R&D capacities and strengthen competencies
4. Increase public awareness to problems of invasives

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