


INVASIVE ALIEN SPECIES IN MALAYSIA

2018

NATIONAL COMMITTEE ON INVASIVE ALIEN SPECIES MALAYSIA

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FOREWORD

Invasive alien species are plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health. Invasive alien species are one of the main threat to biodiversity, often adversely affect the habitats and ecosystems. The spread of invasive alien species can have negative impacts on the environment, the human health, animals and plants, and the economy. Borderless international trade and growing tourism industry may have lead to higher numbers of invasive alien incidence. Climate change may also play a role in the spread of these species.

'Invasive Alien Species in Malaysia 2018' is a publication of invasive alien species of concern in Malaysia, comprises fact sheets of invasive alien species that have already been present in the country and those which are not yet present but poses significant risk if introduced. Prior to the preparation of invasive alien species fact sheets, *National Committee on Invasive Alien Species* has established lists of invasive alien species in Malaysia and those that may present a risk for Malaysia. The lists of invasive alien species have been established on the basis of transparent criteria following specific prioritization on processes and internationally agreed procedures to assess and mitigate the risks (Pest Risk Analysis), with the involvement of experts from various agencies in the agriculture, forestry, veterinary, fisheries, wildlife and marine sectors. These lists will be constantly updated to address the emergence of new risks. Invasive alien species information is compiled and reviewed for preparation of invasive alien species fact sheets. The first edition of **'Invasive Alien Species in Malaysia 2018'** provides fact sheets on 46 invasive alien species from a total of 130 species in the established main invasive alien species lists in Malaysia.

It is hoped that this publication will be able to provide reference and information on invasive alien species of concern in Malaysia and will benefit governmental agencies and non-governmental bodies in planning and developing strategies for management of invasive alien species in Malaysia.

Dato' Jamal Harizan Yang Razali
Director General of Agriculture
Department of Agriculture
(Chairman, National Committee on Invasive Alien Species Malaysia)

LIST OF INVASIVE ALIEN SPECIES

Invasive Alien Species Present in Malaysia

Agriculture and Forestry Sector

No	Type	Common name	Scientific name / causal organism
1	PLANT	Kariba Weed	*Salvinia molesta*
2	PLANT	Parthenium Weed **	*Parthenium hysterophorus*
3	PLANT	Bitter Vine	*Mikania micrantha*
4	FUNGUS	Ceratocystis Wilt Disease	*Ceratocystis fimbriata* (syn: *C. manginecans*) and *C. acaciivora*
5	INSECT	Red Palm Weevil (RPW) *	*Rhynchophorus ferrugineus*
6	VIRUS	Papaya Ringspot Virus *	Papaya ringspot virus (PRSV-P)
7	BACTERIA	Papaya Dieback *	*Erwinia papayae, E. mallotivora*
8	BACTERIA	Blood Disease of Banana (BDB) **	Blood disease bacterium (*Ralstonia solanacearum* species complex Phylotype IV)
9	BACTERIA	Moko Disease *	*Ralstonia solanacearum* species complex Phylotype II
10	PLANT	Itchgrass	*Rottboellia cochinchinensis*

Wildlife And Animal Transmitted Disease

No	Type	Common name	Scientific name / causal organism
1	VIRUS	Foot and Mouth Disease (FMD)	*Picornavirus*
2	VIRUS	Rabies	*Rabies Virus* and *Australian Bat Lyssavirus (Lyssavirus)*
3	ANIMAL	Red Eared Slider	*Trachemys scripta elegans*
4	ANIMAL	Bufo Toad	*Rhinella marina*
5	ANIMAL	European Starling	*Sturnus vulgaris*
6	VIRUS	Highly Pathogenic Avian Influenza	*Highly Pathogenic Avian Influenza Virus (Orthomyxoviridae/Influenza Virus A)*

* - Not present in Sabah and Sarawak

** - Not present in Sarawak

LIST OF INVASIVE ALIEN SPECIES
Invasive Alien Species Present in Malaysia

Fisheries and Marine Sector

NO	Type	Common name	Scientific name / causal organism
1	CRUSTACEA	Marbled Crayfish	*Procambarus fallax* forma *virginalis*
2	CRUSTACEA	Red Claw Crayfish	*Cherax quadricarinatus*
3	FISH	Peacock Bass	*Cichla* spp.
4	MOLLUSC	Pacific Oyster	*Crassostrea gigas*
5	FISH	Algae Suckermouth Catfish	*Hypostomus plecostomus*
6	FISH	Asian Red Tail Catfish	*Hemibagrus wyckioides*
7	FISH	Red-striped Earth-eater	*Geophagus surinamensis*
8	FISH	Flowerhorn	*Cichlasoma hybrid*
9	FISH	Freshwater Stingray	*Potamotrygon motoro*
10	FISH	Paddlefish	*Polyodon spathula*
11	CORAL	Snowflake Coral	*Carijoa riisei*

LIST OF INVASIVE ALIEN SPECIES
Invasive Alien Species Not Present in Malaysia

Agriculture and Forestry

NO	Type	Common name	Scientific name / causal organism
1	PLANT	Alligator Weed	*Alternanthera philoxeroides*
2	VIROID	Cadang Cadang Disease	Coconut Cadang-cadang Viroid (CCCVd)
3	VIRUS	Cocoa Swollen Shoot Virus	Cocoa Swollen Shoot Virus (CSSV)
4	FUNGUS	Bud Rot Disease of Oil Palm	*Phytophthora palmivora*
5	INSECT	South American Palm Weevil	*Rhynchophorus palmarum*
6	BACTERIA	Lethal Yellowing Disease of Coconut	*Candidatus* Phytoplasma palmae (16SrIV)
7	FUNGUS	Vascular Wilt Disease of Oil Palm	*Fusarium oxysporum* f. sp *elaeidis*
8	FUNGUS	South American Leaf Blight	*Microcyclus ulei* *(Ξ Pseudocercospora ulei)*
9	INSECT	West Indian Cane Weevil/ Silky Cane Weevil	*Metamasius hemipterus*
10	PROTOZOA	Sudden Wilt Disease of Oil Palm	*Phytomonas staheli*
11	NEMATODE	Red Ring Disease of Palm	*Bursaphelenchus cocophilus* *(Ξ Rhadinaphelenchus cocophilus)*
12	INSECT	Khapra Beetle	*Trogoderma granarium*
13	FUNGUS	Frosty Pod Rot of Cocoa	*Moniliophthora roreri*

LIST OF INVASIVE ALIEN SPECIES
Invasive Alien Species Not Present in Malaysia

Wildlife And Animal Transmitted Disease

No	Type	Common name	Scientific name / causal organism
1	BACTERIA	Anthrax	*Bacillus anthracis*
2	VIRUS	West Nile Fever	West Nile Virus (*Flavivirus*)
3	VIRUS	African Swine Fever	African Swine Fever Virus (*Asfivirus*)
4	VIRUS	Rift Valley Fever	Rift Valley Fever Virus (*Phlebovirus*)
5	VIRUS	Ovine Rinderpest (Sheep and Goats Plague)	Peste des Petits Ruminants Virus (*Morbilivirus*)
6	ANIMAL	Red Eared Slider	*Trachemys scripta elegans*
7	PRION	Mad Cow Disease	Bovine Spongiform encephalopathy

I. FACTSHEET OF INVASIVE ALIEN SPECIES IN AGRICULTURE AND FORESTRY SECTOR

Status in Malaysia	Present

Kariba Weed

Salvinia molesta

Salvinia molesta is a floating aquatic fern that thrives in slow-moving, nutrient-rich, warm, freshwater. It is cultivated by aquarium and pond owners and sometimes released by flooding, or intentional dumping. It has been spread widely throughout the world and is invasive in a variety of aquatic habitats, including lakes, rivers and paddy fields.

Source:Department of Agriculture of Sabah

S. molesta plant

Identification *Salvinia molesta* is a rootless, free-floating fern that can be identified by its broadly rounded green fronds. Pairs of these emergent fronds are produced at each node of a horizontal stem that floats just beneath the water surface. While the leaves of young plants lie flat on the water's surface, the leaves of mature plants grow to be between ½ and 1½ inches long (1.27 and 3.8 cm) and are forced upright. The surface of the salvinia leaf has rows of cylindrical "hairs" topped with four branches that are joined at the tips to form a cage or eggbeater shape.

Source:Department of Agriculture of Sabah

S. molesta plant

Source:Department of Agriculture of Sabah

S. molesta covered at least 90% of Lake Tungog, Sabah

Source:Department of Agriculture of Sabah

Removing *S.molesta* manually from water body.

Source:Department of Agriculture of Sabah

Cyrtobagous salviniae can be used as biological control agent for *S.molesta.*

Distribution Worldwide spread - Africa, Asia including South East Asia, Americas, Europe and Oceania.

Threat *S. molesta* can greatly alter aquatic ecosystems. As the mature plants weave themselves into a thick, floating mat, oxygen and light are blocked from the water. It often outcompeting rooted and submerged native plants and reducing vascular plant diversity. The rapid spread of this pest threatens cultivated aquatic crops, and it can clog irrigation and drinking water lines and foul hydroelectric plants. *S. molesta* infested waters cannot be used for boating or other recreational purposes.

Control Measures in Country Mechanical control of *S. molesta* primarily consists of removing the weeds from the water body. This could be done manually by hand, using hand tools or machine. *Cyrtobagous salviniae* weevil has been introduced to control *S. molesta* in Malaysia.

Status in Malaysia	Present

Parthenium Weed

Parthenium hysterophorus

Parthenium hysterophorus, a member of the Asteraceae (Compositae) family, is becoming an increasingly troublesome weed around the world. It was considered as one of the world's most invasive weeds. Malaysia has gazetted this weed as dangerous pest in 2015.

Source:Department of Agriculture Malaysia

Parthenium hysterophorus flowers

Identification Plants first form a basal rosette, up to a foot in diameter, of finely lobed leaves. Plants then form a paniculately branched pubescent stem with lengthwise grooves growing to heights of 5–6½ feet. The leaves on the stem are alternate. This plant may eventually reach a height of 2 metres. The leaves are pale green, branched and covered with soft fine hairs. The small white flowers (4 mm across) have five distinct corners and grow on the stem tips. Each flower produces four or five black wedge shaped seeds that are 2 mm long with thin white scales.

Distribution Parthenium weed is capable of growing in most soil types but become most dominant in alkaline, clay loam soils. This plant is native to Mexico, Central and South America. Now it can be found in more than 30 countries in North, Central and South America, Africa, Asia and Australia. First detected in Malaysia in 2013 at Batang Kali, Selangor.

Source:Department of Agriculture Malaysia

P. hysterophorus plant

Source:Department of Agriculture Malaysia

P. hysterophorus can be dominant and surpress other plant growth

Source:Department of Agriculture Malaysia

P. hysterophorus seeds

Source:Department of Agriculture Malaysia

Skin rashes in contact with *P. hysterophorus*

Threat Infestation by Parthenium weed degrades natural ecosystems. The weed aggressively colonizes disturbed sites and reduces pasture growth and depresses forage production. The germination and growth of indigenous plants are inhibited by its allelopathic effect. The pollen grains, air borne pieces of dried plant materials and roots of Parthenium weed can cause allergy-type responses like photodermatitis, asthma, skin rashes, puffy eyes, constant cough, running nose and eczema on human. In animals, the plant can cause anorexia, pruritus, alopecia, dermatitis and diarrhoea. Parthenium weed can taint sheep meat and make dairy milk unpalatable due to its irritating odour.

Control Measures in Country Parthenium weed has been gazetted as dangerous pest in Malaysia and legal action can be taken and enforced through the Plant Quarantine Act 1976 (Act 167).

Status in Malaysia	Present

Bitter Vine

Mikania micrantha

Mikania micrantha is a perennial creeping climber known for its vigorous and rampant growth. It grows best where fertility, organic matter, soil moisture and humidity are all high. It has been recognised globally as a major threat to biodiversity and listed in 100 of the world worst Invasive Alien Species. In Malaysia it was introduced as a non-leguminous ground cover for plantations of *Hevea brasiliensis* (rubber). Today most abandon areas have been invaded by this weed.

Source:Forest Research Institute Malaysia

Mikania smothering vegetation in a degraded natural forest

Identification A branched, slender-stemmed perennial vine. The leaves are arranged in opposite pairs along the stems and are heart-shaped or triangular with an acute tip and a broad base. Leaves may be 4 to 13cm long. The flowers, each 3 to 5mm long, are arranged in dense terminal or axillary corymbs. Individual florets are white to greenish-white. The seed is black, linear-oblong, five-angled and about 2mm long. Each seed has a terminal pappus of white bristles that facilitates dispersal by wind or on the hair of animals.

Distribution Native in Central and South America, *M. micrantha* is currently widespread in Asia and the Pacific, Australia and South, North and Central America.

Source:Department of Agriculture, Malaysia

M. micrantha in rubber plantation

Source:Department of Agriculture, Malaysia

M. micrantha choking banana plant

Source:Department of Agriculture, Malaysia

M. micrantha seed

Source:Department of Agriculture, Malaysia

M. micrantha flower

Threat *Mikania micrantha* climbing and twining on any vertical support, including crops, bushes, trees, walls and fences. Its shoots have been reported to grow up to 27mm a day. Vegetative reproduction is also efficient and vigorous. *M. micrantha* damages or kills other plants by cutting out the light and smothering them. In this respect it is especially damaging in young plantations and nurseries. It also competes for water and nutrients.

Control Measures in Country Mechanical weeding before flowering and seed setting gives temporary control. Uprooting during the initial stages of growth (before flowering and fruiting) is the most effective mechanical control method. However, mechanical control method is very labour intensive and uneconomical. Both pre and post-emergent herbicides are generally used for Mikania control. Glyphosate is widely used against Mikania, especially in forest plantations. All herbicidal applications should preferably be carried out before flowering and seed setting.

Status in Malaysia	Present

Ceratocystis Wilt Disease of Acacia

Ceratocystis fimbriata (≡ C. manginecans) and *C. acaciivora*

Ceratocystis fimbriata is the causal agent of Ceratocystis wilt disease and canker disease, which can cause the death of plant and subsequently causing major losses in agricultural production. In the last two decades, emerging diseases related to *Ceratocystis* infections have been greatly increased.

Source: Forest Research Institute Malaysia

Wilting and death of trees.

Main Hosts *Acacia* spp. (Acacia trees)

Identification In most cases where highly susceptible trees are infected, leaves will wilt, followed by the death of the entire tree. These symptoms may or may not be accompanied by stem and branch cankers. Internal symptoms of infection by *Ceratocystis* sp. is the presence of light to dark brown vascular streaks in the xylem of trees. More tolerant trees often develop stem cankers, characterised by gum pockets (blisters) below the bark of trees, black/red lesions on the bark of trees and the exudation of gum from the lesions and ruptured blisters.*Ceratocystis* species are wound infecting and insect associated pathogens. In South Africa, infection and disease caused by *Ceratocystis* sp. is common after animal damage to trees. Infection also occurs after wounds inflicted during mechanical weeding and thinning operations, and wind damage. Infection may occurs commonly in summer, where the insect vectors are active.

Source: Forest Research Institute Malaysia

Bark discoloration and gum exudation

Source: Forest Research Institute Malaysia

Cankers on stems of diseased tree.

Distribution Malaysia, Indonesia, Vietnam, South Africa, Uganda, Kenya, Tanzania and Zambia.

Threat The infection can cause in stem cankers and rapid wilt and death of susceptible plantation grown of Acacia trees.

Control Measures in Country Selection of disease tolerant planting material is possible. Great variation in susceptibility of different Acacia families has been shown in artificial inoculation experiments. Wounds should be prevented or minimized as much as possible, especially during dry weather months. Thinning and weeding operations which may result in wounds should be restricted to cooler, drier periods of the year.

Status in Malaysia	Present

Red Palm Weevil (RPW)

Rhynchophorus ferrugineus

Rhynchophorus ferrugineus is currently the most severe pest of major cultivated palms, especially coconuts. This pest has spread extensively in the Middle East and Europe in the last 30 years. RPW infestation in Malaysia was first detected in 2007 by the Department of Agriculture (DOA) in Terengganu. In 2011, over 550,000 coconut trees have been attacked by RPW. Regular monitoring surveys showed that there is a drastic increase and rapid spread of RPW population in most of the states in Malaysia.

Source:CABI CPC (Crop Protection Compendium

A red palm weevil adult next to a larva (white grub), and pupa (beige).

Main Hosts Palms - coconut (*Cocos nucifera*), sago (*Metroxylon sagu*), date palms (*Phoenix* spp.) and ornamental palms.

Identification Holes at the base, tunneling in the stem or base of the fronds, leaves with straight edges rather than pointed tips, frass at the entrance of tunnels, wilting and death of the leaves, especially at the crown. The adult is about 40 mm long and 15 mm wide, reddish-brown with dark spots on the part of the body behind the head, and they have a long snout, characteristic of weevils. They vary greatly in colour. The life cycle is about 4 months. The female lays 200 to 300 whitish, smooth eggs (3 mm by 1 mm) in separate holes in the trunk or in petioles (leaf stalks). The eggs hatch in 2 to 5 days. The larvae are legless, white with a brown head, growing up to 50 mm long. They bore into the interior of the palm feeding on the soft tissue, but leaving the fibrous material.

Source : Wikipedia

Bases of palm leaves fallen from the crown of the tree, with burrows and extracted pupal cases.

Distribution Widespread - Asia, Middle East, North Africa, the Caribbean, Europe, Oceania, Papua New Guinea, Samoa, Solomon Islands and Vanuatu.

Threat Red Palm Weevil has caused a tremendous impact to coconut industry in Malaysia. Part of the economic importance of this pest is the cost of removing infested palms and replanting; there are also major costs involved in trying to cure infested palms.

Source : Wikipedia

Destroyed crown of a Canary Island date palm

Quarantine Gazetted as a dangerous pest in 2011 under the Plant Quarantine Act 1976. Standard of Procedures to Control, Containment and Eradication Programme of RPW has been developed by Department of Agriculture Malaysia.

Status in Malaysia | **Present in Southern part of Johor State**

Papaya Ringspot Disease

Papaya ringspot virus (PRSV-P)

Source: Department of Agriculture Malaysia

Ringspot / dark green rings symptom on papaya fruits

Papaya ringspot disease caused by Papaya ringspot virus-type P (PRSV-P) is a devastating pest of papaya that was first detected in Johor in 1991. Since then, the areas planted with papaya has reduced drastically as all plants in infested area were removed in order to eliminate the source of virus. Since papaya is an important industry in Malaysia, valued approximately RM32.1 million annually, the PRSV-P indeed is a great threat to the industry.

Main Hosts Limited host range. Only infecting the plants from the family Caricaceae, Cucurbitaceae and Chenopodiaceae.

Identification Papaya plants are susceptible to PRSV-P at any age and generally show symptoms 2 to 3 weeks after inoculation. Symptoms on leaf are characterized by intense yellow mosaic and leaf distortion. Infected leaf laminae will reduced in size, developing a shoestring appearance. Dark-green blisters and mosaic appear on the leaves. Oily streaks symptom on the stems and petioles. Dark-green rings present on the fruits and it became distinct as fruit mature and yellow. The canopy of diseased plants will reduce due to small development of leaves and petioles. Fruit yield reduced and infected young tree never produce marketable fruits and may die. Transmitted by several species of aphids (including *Myzus persicae, Aphis corcopsidis, Aphis craccivora, Aphis fabae, Aphis gossypii* and *Toxoptera citricidis*) in a non-persistent manner. It does not multiply in vector and typically not transmitted through seeds. PRSV-P can be transmitted directly from infected plants to healthy papaya without incubation period.

Source: Department of Agriculture Malaysia

Mosaic symptom on leaves

Source: Department of Agriculture Malaysia

Water - soaked symptom on lower part of infected leaves

Source: Department of Agriculture Malaysia

PRSV infected papaya trees

Distribution Widely distributed in North America, some countries in Asia, Africa, Oceania and Europe. In Malaysia, it is contained in southern part of Peninsular Malaysia.

Threat Papaya ringspot disease is the most destructive disease of papaya and occurs in every region where the papaya is grown. PRSV-P was reported to be major limiting factors for commercial papaya and cause serious losses in papaya industry.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Current Measures in Country Infected area and plants must be eradicated immediately as soon as the disease is detected.

Status in Malaysia	Present

Papaya Dieback

Erwinia papayae and *E. mallotivora*

Papaya dieback disease was first reported in Malaysia in 2003 and later it was confirmed that *Erwinia papayae* and *Erwinia mallotivora* are responsible for papaya dieback symptoms. This disease has spread in Peninsular Malaysia thus the papaya industries were seriously affected leading to significant reduction in production and losses in export market.

Source: Department of Agriculture Malaysia

Water-soaked lesion on leaf stalks and crowns

Main Hosts Papaya (*Carica papaya*)

Identification Early symptoms included yellowing and necrosis along leaf edges followed by water-soaked areas on the bases of leaf stalks, crowns and along leaf mid-ribs. Fruit symptoms included dark spots on the skin and water-soaked flesh. Later, necrotic and water-soaked areas developed on stems and spread to the internal tissues, followed by secondary fungal infections. In advanced stages, banding of water-soaked leaf stalks occurs, leading to dieback, and death of trees. The disease can be spread by human activities and possibly birds and insects.

Source: Department of Agriculture Malaysia

Water-soaked symptom on fruit

Source: Department of Agriculture Malaysia

Secondary fungal infection on infected fruit

Source: Department of Agriculture Malaysia

Death of severely infected papaya trees

Distribution Malaysia and Caribbean.

Threat Total yield losses in Malaysia were estimated at 200,000 metric tonnes, equivalent to RM 235.8 million. The varieties affected were Eksotika, Solo, Hong Kong and Sekaki.

Quarantine Gazetted as a dangerous pest in 2009 under the Plant Quarantine Act 1976. Standard of Procedures to Control, Containment and Eradication Programme of Papaya Dieback has been developed by Department of Agriculture Malaysia.

Current Measures in Country On commercial plantations and non-commercial lands, early detection and prompt removal of infected plants can contain a localized outbreak. However, once the disease is detected, infected trees and severely affected plants should be destroyed, as they could provide a source of infection for further spread.

Status in Malaysia	Present

Blood Disease of Banana (BDB)

Blood disease bacterium *(Ralstonia solanacearum* species complex Phylotype IV)

Blood disease was first reported 80 years ago from southern Sulawesi and has caused abandonment of banana plantations in the area. Until recently, the distribution of blood disease is very limited but it is now spreading rapidly and posses a serious threat to neighboring islands in Indonesia and also to other countries including Malaysia.

Source: Department of Agriculture Malaysia

Internal discoloration and rot of immature fruits

Main Hosts Musaceae

Identification BDB produces very similar symptoms to Moko and Bugtok disease. A very common symptom is a red brown dry shriveled pulp in unripe fruits that look outwardly green and healthy. After some time, this is seen in every fruit of the bunch. The external symptoms usually develop at the beginning of ripening, when the fruits turn yellow or brown, collapse and decay. Mature leaves of all ages show conspicuous transient yellowing, loss of turgidity, desiccated and necrosis. Immature plants, base of the petiole collapse causing wilted leaves to hang down around the pseudostem. Vascular bundles exhibit reddish-brown discoloration and may be confined to the central fruit stem. Cut vascular tissues exude bacterial ooze. The bacterium is a soil-borne pathogen and able to be dispersed in contaminated soil and run-off. It can also be spread through vegetative planting materials and contaminated farm equipment.

Source: Department of Agriculture Malaysia

Discoloration of vascular bundle

Source: Department of Agriculture Malaysia

Internal discoloration and rot of immature fruits

Distribution Indonesia and Malaysia (Peninsular Malaysia and Sabah).

Threat The disease is a major limiting factor in cultivation of banana as it persists all year round.

Quarantine Listed as dangerous pest in Forth Schedule of Plant Quarantine Act 1976 and Plant Quarantine Regulations 1981. Standard of Procedures to Control, Containment and Eradication Programme of Banana Bacterial Wilt has been developed by Department of Agriculture Malaysia.

Control Measures in Country Implementing good agricultural practices such as farm sanitation, eradication of infected plants, control movement of planting materials and the use of disease-free planting materials.

Status in Malaysia	Present

Moko Disease

Ralstonia solanacearum species complex Phylotype II

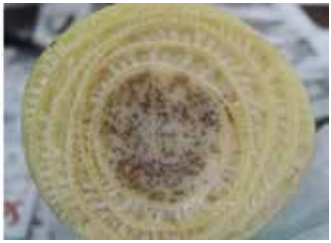
Moko is a deadly bacterial disease of banana and plantains. It is caused by a soil-borne bacterium *Ralstonia solanacearum* spesies complex Phylotype II. It is very similar to Blood Disease of Banana (BDB).

Source: Department of Agriculture Malaysia

Internal browning rot of fruits

Main Hosts Musaceae and Heliconiaceae

Identification Fruit rot and fruit stalk discoloration as well as wilting or blackened regrowth suckers are characteristic (non-exclusive) symptoms for Moko. Young plants – wilt can progress rapidly. Light to dark brown vascular discoloration occur in the pseudostem, rhizome and sheaths of the leaves. Bacterial ooze exudes as droplets from the cut surface of vascular tissues, mainly peduncle or pseudostem. Fruit becomes smaller and fruit pulp can show a firm brown or grey rot. If infection occurs via the roots and rhizomes, yellowing and wilting of the oldest leaves will occur first and plant will collapse. It can be transmitted by insect visiting these flowers. The bacterium forms irregular round, creamy colonies with red centres when cultured on Kelman's tetrazolium chloride (TZC) medium.



Source: Department of Agriculture Malaysia

Discoloration of vascular bundle of cut pseudostem

Source: Department of Agriculture Malaysia

Banana bunch infected with Moko Disease

Distribution Asia - India, Indonesia, Malaysia, Philippines, Thailand, Vietnam
Africa - Ethiopia, Libya, Nigeria, Senegal
North America - Mexico, USA
Central America and Carribean - Belize, Costa Rica, El Savador, Grenada, Guadeloupe, Guatemala, Honduras, Jamaica, Nicaragua, Panama, Saint Vincent & the Grenadines, Trinidad and Tobago
South America - Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela.

Threat The disease constitutes a major phytosanitary problem in plantain and banana crops, causing production losses and high eradication costs.

Control Measures in Country Implementing good agricultural practices such as farm sanitation, eradication of infected plants, control movement of planting materials and the use of disease-free planting materials.

Status in Malaysia	Present

Itchgrass

Rottboellia cochinchinensis

Rottboellia cochinchinensis is an aggresive significant weed in more than 40 countries under various ecological conditions, in at least 18 crops. It is also a weed of bananas, cassava, citrus, cowpeas, papayas, groundnut, pineapple, rice, sugarcane, and sorghum. The infestation of this grass in Malaysia was first reported in 1980 and became an important weed in sugarcane plantations in Perlis and Kedah.

Source:Department of Agriculture, Malaysia

Mature *R. cochinchinensis* can grow up to 3m height

Identification Itchgrass may reach the height of 3 meters. Leaves are simple with a pale green and linear-lanceolate shape, flat limbs with saw boarders, rough pubescence and a dimension of approximately 20 to 60 cm of length and 1 to 3 cm of width. Leaf sheaths keeled to rounded, ribbed, covered with long, sharp, silicaceous, fragile, irritating hairs that break off on contact, upper sheaths glabrous or hairy, auricles absent. The inflorescence is a raceme, consists on widely conic bunches similar to spikes, terminals or axilars (frequently group) from 5 to 10 cm of length and hairless. The spike becomes thinner towards the apex; and it is composed by internodes and each segment presents a deep excavation in the superior part. The fertile sessile spikelet is oblong and around 2.5 mm in length. The plant grows extremely rapid under good conditions and it is well known to aggressively overgrown other grasses. Seed production continues throughout the growing season. Seeds break off as they mature and may retain viability in the soil for up to four years.

Source:Department of Agriculture, Malaysia

Hairy stem and leaf node

Source:Department of Agriculture, Malaysia

Itchgrass inflorescence

Source:Canadian Food Inspection Agency

Itchgrass spikelets embedded in stem piece and a caryopsis

Distribution Present in tropical areas of the Americas and Caribbean, as well as being widespread in tropical Asia and the Pacific Islands, tropical Africa, and Australia.

Threat This weed is very competitive with the agricultural crops and its infestations can result in up to 80% crop loss. It has ability to grow, flower, and set seeds under wide range of environmental conditions. It is also very tolerant to most herbicides and the irritating hairs on its stem make it difficult to control manually. This weed is also an alternative host of the plant viruses causing corn leaf gall and rice leaf gall.

Control Measures in Country This weed is being controlled mechanically and chemically.

Status in Malaysia	Not Present

Alligator Weed

Alternanthera philoxeroides

Alligator weed forms dense mats along the shoreline of lakes, ponds, streams, ditches and wetlands, with the mat extending out into open water. The dense growth suppresses native plant species, reduces the quality of habitat for waterfowl, wildlife and fish, and will reduce oxygen levels in the water under the mat. The dense mats also interfere with navigation and recreational use.

Source:© Hunter Regional Weeds 2018

Alligator weeds clog waterways and increase sedimentation and flooding risk

Identification Stems can lie flat or upright. The flat stems can be light green, yellow or brown to red. Upright stems are dark green, can be up to 80 cm or longer. Stems have pairs of leaves at each node. Leaves with no leaf stalk (petiole), they are spear-shaped in opposite pairs along the stems. They are generally dark green, waxy, glossy, and range in size from 2 to 12 cm in length and 0.5 to 4 cm wide with an acute tip.

Source:i.pinimg.com

Alligator weed (*Alternanthera philoxeroides*)

Source:© Hunter Regional Weeds 2018

Alligator weeds clogs waterways and increase sedimentation and flooding risk

Source:Sheldon Navie

Lower stem with roots developing at its joints

Source:Julia Scher

Close-up of mature fruit, which is mostly hidden by the old flower parts

Distribution Present in Bangladesh, China, India, Indonesia, Japan, Laos, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam, Mexico, USA, Honduras, Puerto Rico, Trinidad and Tobago, Argentina, Bolivia, Brazil, Colombia, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela, France, Italy, Australia and New Zealand.

Threat Alligator weed threaten the environment by restricts water flow in creeks, channels and drains. It may also reduce water quality, and as a result, kills fish and aquatic plants. It can be dominant species and replaces native wetland plants. This plant can cause damage to pumps and irrigation equipment. It also impedes water sports activities and creates favourable habitat for mosquito.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia | Not Present

Cadang Cadang Disease

Coconut cadang-cadang viroid (CCCVd)

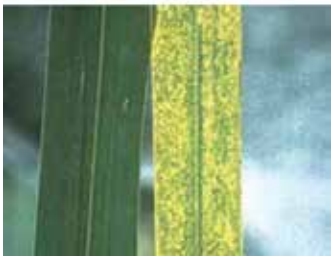
Cadang cadang disease (caused by coconut cadang-cadang viroid; CCCVd) outbreak first reported in 1930's in southern Luzon in the Philippines. CCCVd (246-nucleotide form) is the smallest known viroid, as well as the smallest known infectious pathogen. It is transmitted by vegetative multiplication of infected hosts, by seed and pollen and, possibly, by the action of unknown vector(s).

Source: John Randles, University of Aelaide, Bugwood.org

Cadang-cadang ("dying-dying") disease of coconut palm, caused by a viroid

Main Hosts *Cocos nucifera* (Coconut palm)

Identification Water-soaked spots (leaf spots) are produced on leaflets, and the leaves become small as the disease progresses (reduced leaflets); the crown of leaves is parted into two groups (a tuft of young leaves and a group of old, horizontal or drooping leaves), and the stipules are profuse and persistent. Growth of infected palms are stunted. The fruits are big and profuse in the mild stage; in the severe stage of the disease, the fruits are few, small, misshapen and scarified. Finally it causes death of infected palms.



Source: John Randles, University of Aelaide,

Severe non-necrotic yellow spots of leaflets from (left) healthy palm and (right) palm with late-stage disease showing non-necrotic chlorotic spotting.

Source: Source: John Randles, University of Aelaide, Bugwood.org

Nuts from (left) healthy palm and (right) diseased palm showing rounding, equitorial scarifications and reduced husks.

Source: Source: John Randles, University of Aelaide, Bugwood.org

Premature loss of male florets at early stage of disease.

Distribution Widely distributed in the Philippines.

Threat A serious economic threat for coconut, causing their premature decline and death. About 40 million palm trees are estimated to have died from cadang-cadang in the Philippines with a loss of about USD100 per infected palm due to lost production and delay in replacement. The mode of natural transmission is unknown, and eradication measures fail to control the disease. Cadang-cadang is a serious economic threat on coconut industry in Malaysia.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia **Not Present**

Cocoa Swollen Shoot Virus Disease

Cocoa swollen shoot virus (CSSV)

Cocoa swollen shoot virus disease is a serious disease that can infect cocoa at any stage of plant growth. Natural transmission of this virus is by mealybug vectors and infected budwood. Several different strains of the virus exist and can cause defoliation, dieback of the plant, and most severe strains of the virus can kill the plant within 2 to 3 years.

Source: Nicola Spence

Cacao (*Theobroma cacao* L.) showing swollen shoot diseased stem

Main Hosts Cocoa (*Theobroma cacao*)

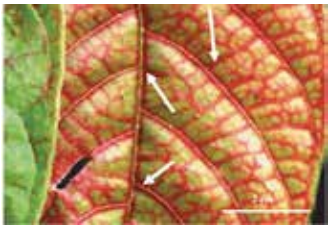
Identification Symptoms are mostly seen in leaves, but stem and root swellings as well as pod deformation also occur. Stem swellings may develop at the nodes, internodes or shoot tips. Leaf symptoms include: yellow clearing along main veins; tiny pin-point flecks to larger spots; diffused flecking; blotches or streaks; and chlorotic vein flecking or banding. Infected trees may suffer from a progressively severe defoliation and dieback. Smaller, rounded to almost spherical pods may be found on trees infected with severe strains.

Source: Z. Oro et. al. (2012)

Swelling of the cacao plant stem

Distribution Mainly distributed in west Africa - Côte d'Ivoire, Ghana, Nigeria, Sierra Leone, Benin, Togo, and Cameroon. It also present in Sri Lanka.

Threat A major constraint to cocoa production in west Africa. It can reduce yield by about 70% and cause death of cocoa tree in 2 to 3 years.



Source: Z. Oro et. al. (2012)

Intense redness along the principal veins and between the secondary veins of the young cacao leaf

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia | Not Present

Bud Rot Disease of Oil Palm

Phytophthora palmivora

The first localized epidemics of bud rot in oil palm in Colombia were reported in 1964.

Source: idtools.org

Necrotic symptoms on spear and young leaves of Oil Palm

Main Hosts Oil Palm (*Elaeis guineensis*), Coconut (*Cocos nucifera*)

Identification The typical symptom is yellowing of young leaves during the months of high rainfall and high relative humidity. Affected leaf tissue eventually becomes necrotic and dies as the disease progresses. The disease is most serious when growing meristematic palm tips are infected and the fungal pathogen extends deep into plant tissues.

FUNGUS

Source:idtools.org

The spear leaf and the next youngest leaves of ornamental palm are desiccated and necrotic due to bud rot disease.

Source:idtools.org

Symptoms of bud rot on mature *Cocos nucifera* trees

Disribution Colombia, USA, and Caribbean.

Threat Bud rot disease is a serious threat of oil palm producing countries in the world. Recent outbreaks of this disease in Colombia have been estimated to cause losses of USD 250 million and it has destroyed more than 70, 000 hectares of oil palm.

Quarantine Restriction on importation of oil palm under Plant Quarantine Act 1976.

Status in Malaysia | Not Present

South American Palm Weevil

Rhynchophorus palmarum

R. palmarum larvae often destroy the apical growth area of the tree by feeding on the growing tissue in the palm crown. The females are attracted to fresh trunk wounds and lay their eggs inside the plant tissue in a hole made with their rostrum. *R. palmarum* is the vector of the nematode *Bursaphelenchus cocophilus,* the causal agent of the red-ring disease, which causes serious economic losses in palm plantations.

Source:©Bernard Dupont/via Wikipedia

Adult *Rhynchophorus palmarum*

Main Hosts Coconut (*Cocos nucifera*), Oil palm (*Elaeis guineensis*), Sago palm (*Metroxylon sagu*) and sugarcane (*Saccharum officinarum*)

Identification Eggs are located individually 1 to 2 mm inside soft plant tissue, near the apical area of the palm. The eggs are 2.5 x 1 mm in size, white and with rounded extremes. The larva is typically eruciform, and is 2.40 mm long and 0.94 mm wide in the first instar. The head is rich orange brown in colour and bears a pair of stout mandibles. The abdomen is creamy white and semitransparent, each segment bearing distinct tufts of lateral setae. The adult is deep black in colour. Its body surface is also pitted and covered with short hairs. The size is about 1.5 inches in length and 0.5 inches wide. The males have a “moustache” or a comb of hair located on the rostrum.

Robin M. Giblin-Davis

The males have a “mustache” or a comb of hair located on the rostrum.

Source:D. R. Hodel

Initial symptoms of an SAPW infestation can also include chewed off or missing mid-blade pinnae

Source:Center for Invasive Species Research, University of California, Riverside

Canary Island palm killed by *R. palmarum*

Distribution Argentina, Barbados, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominica, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay and Venezuela.

Threat Economic damage is dependent on both the species of palm and the number of larvae present. Infested palms can eventually die; 30 larvae are able to kill an adult coconut palm. Several millions of US dollars are lost annually due to the association of red-ring disease of oil palm and *R. palmarum.*

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia **Not Present**

Lethal Yellowing Disease of Coconut

Candidatus Phytoplasma palmae (16SrIV)

Lethal yellowing is a phytoplasma disease that attack many species of palm. Over 38 species of palm are susceptible to lethal yellowing and there are no resistant coconut varieties to this disease.

Source:cabi.org

Lethal yellowing mid-stage foliar discoloration symptoms on the Atlantic tall coconut ecotype

Main Hosts Coconut (*Cocos nucifera*)

Identification No single symptom is diagnostic of lethal yellowing. Symptoms are variable among palm genera and, in the case of coconuts, among cultivars. It is the pattern of appearance and chronological progression of symptoms that accurately identifies the disease. At least 36 palm species have been documented as susceptible to lethal yellowing, but coconut palm (*Cocos nucifera*) is most vulnerable to the disease, followed by *Pritchardia* species, Christmas palm (*Adonidia merrillii*), and date palm (*Phoenix dactylifera*). On nuts, premature shedding of all fruit (nutfall) regardless of their developmental stage. Aborted nuts often develop a necrotic brown-black calyx-end rot reducing seed viability. Premature nutfall is accompanied or followed by inflorescence necrosis.

Source:cabi.org

Lethal yellowing damaged nuts aborted coconuts often develop a calyx-end rot

Distribution Africa (Benin, Cameroon, Ghana, Kenya, Mozambique, Nigeria, Tanzania, Togo), North America (Mexico, USA), Central America (Belize, Honduras, Guatemala), and Caribbean (Cuba, Cayman Islands, Dominican Republic, Haiti, Jamaica, Nevis).

Threat Lethal yellowing and related diseases pose a significant threat to global coconut production.

Source:http://www.apsnet.org/

The calyx end of the nut (fruit) will usually develop a brown to black, water-soaked appearance

Quarantine Restriction on importation of coconut under the Plant Quarantine Act 1976.

Status in Malaysia **Not Present**

Vascular Wilt Disease of Oil Palm

Fusarium oxysporum f. sp. *elaeidis*

Vascular Wilt Disease of Oil Palm is caused by *Fusarium oxysporum* f. sp. *elaeidis* affects seedlings and mature palm. For mature palms *Fusarium oxysporum* f. sp. *elaeidis* have two forms; chronic and acute forms.

Source: CABI CPC (Crop Protection Compendium)

Symptoms of Vascular Wilt of Oil Palm

Main Hosts Oil Palm (*Elaeis guineensis, Elaeis oleifera*) and weed species (*Amaranthus spinosus, Eupatorium odoratum, Mariscus alternifolius* and *Imperata cylindrica*)

Identification Brown discoloration of xylem vessels in the trunk, and in the leaf bases of severely infected palms. Older leaves desiccated, the rachis breaks near or at some distance from the base and hangs down around the trunk. The disease progresses gradually, with younger leaves becoming successively affected whilst the erect young leaves in the crown are much reduced in size and may become chlorotic; the apex of the trunk may also reduce in diameter. The palm can exists the condition for several years.

Source: CABI CPC (Crop Protection Compendium)

Internal symptoms in base of seedling

Source: CABI CPC (Crop Protection Compendium)

Symptoms on mature oil palm

Source: CABI CPC (Crop Protection Compendium)

Wilt of immature palm caused by *F. oxysporum* f. sp. *elaeidis*

Source: CABI CPC (Crop Protection Compendium)

Discoloration of xylem vessels from the trunk of a mature palm.

Distribution Central and West Africa (Côte d'Ivoire, Nigeria, Ghana, Rep. of Cameroon and Rep. of Congo), Brazil, and Ecuador.

Threat Vascular wilt is the most important disease of oil palm in western and central Africa. Losses of up to 50% have been recorded for palms under 10 years old in some plantations. It also reduce 6 to 16% yield reduction in 6-year-old palms with 2.5 to 5.5% of plants showed external symptoms has been observed.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia | Not Present

South American Leaf Blight (SALB)

Microcyclus ulei (Ξ Pseudocercospora ulei)

South American Leaf Blight (SALB) caused by the fungus *Microcylus ulei* is the main limiting factor to the natural rubber industry in South and Central America.

Main Hosts Rubber (*Hevea brasiliensis*), *Hevea* spp.

Source: Department of Agriculture Malaysia

Early stage infection of *Microcylus ulei* on Hevea leaves

Identification The causal pathogen *Microcyclus ulei* is known to only infect species within the genus Hevea. It produces three types of spores; conidia on immature leaves; pycnospores on newly matured leaves; and ascospores on fully matured leaves. The main propogules are conidia and ascospores. Pycnospores do not appear to germinate and do not therefore constitute an effective agent of disease dissemination. The conidia and ascospores infect the young developing leaves causing distortion followed by necrosis of the lamina. The primary stage of the disease on young leaves is characterized by the appearance of lesions covered by dark grey powdery masses of conidia on the abaxial leaf surface. Sporulation lasts for 2 to 3 weeks, later it becomes sparse and eventually no more conidia are produced. The conidia are disseminated by wind, vectors and water.

Asexual Infection Stage of *Microcylus ulei*

Source: Department of Agriculture Malaysia

Heavily infected Hevea leaves with greyish conidiospore layers on upper and lower surface

Sexual Infection Stage of *Microcylus ulei*

Source: Department of Agriculture Malaysia

Spore-producing lesions on mature leaves.

Source: Department of Agriculture Malaysia

Black pigmented globose structure form ring-like stromata

Distribution North America (Mexico), South and Central America, and Caribbean.

Threat There is neither chemical nor biological control measures proven can effectively eradicate the disease. It has become a great threat to rubber growing countries especially in the Asia and the Pacific region as most of the cultivated natural rubber tree genotypes in this region is susceptible to the disease. Even though this disease is still restricted to its continent of origin, it is highly potential to be spread around the world via trade and human movement.

Quarantine Currently, the fungus has not spread to Africa, Asia and Pacific Region due to strict quarantine measures enforced by these countries to prevent the entry of the pathogen. In Malaysia, it is listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia	Not Present

West Indian Cane Weevil / Silky Cane Weevil

Metamasius hemipterus

Metamasius hemipterus is widely distributed throughout the West Indies, Central and South America. The weevil is recognised as one of important pest of sugarcane and attracted to stem damage by mechanical cultivation, harvesting equipment, field rats, other plant borers, diseases, or natural growth cracks. The larvae can cause extensive damage by boring tunnels through plant stems and petioles.

Source:Iowa State University Department of Entomology

Metamasius hemipterus adult

Main Hosts Banana and plantain (*Musa* spp.), sugarcane (*Saccharum officinarum*) and ornamental palms such as Canary Island date palm.

Identification Feeding on sugarcane causes retarded growth, plants turn yellow in colour and become stunted, and the stalks are riddled with large galleries. In banana, plants show slowed growth, leaves wilt and wither; the pseudostems are heavily mined and often broken, and young plants turn yellow and collapse. Adults can live for 60 days. Females are attracted to damaged or stressed sugarcane where they deposit average of 500 eggs in her life time. Eggs hatch in about 4 days and young larvae begin feeding. After about 7 weeks feeding, larvae pupate in a pupal case. After 10 days, adults emerge from the cocoon or may remain within the cocoon until environmental conditions are favourable for emergence.

Source: Robin M. Giblin-Davis, University of Florida

Damage to sugarcane by silky cane weevil

Source: Robin M. Giblin-Davis, University of Florida

Damage to Canary Island palm by silky cane weevil

Source: Robin M. Giblin-Davis, University of Florida

Damage to spindle palm by silky cane weevil

Distribution Africa, North America, Central America, and South America.

Threat It has the potential to be economic pest of banana, cassava, coconut, maize, pineapples and sugarcane. If the pest became established in Malaysia, costly control measures would have to be adopted.

Status in Malaysia **Not Present**

Sudden Wilt Disease of Oil Palm

Phytomonas staheli

Phytomonas staheli is a protozoan parasite, an aetiologic agent of Sudden Wilt Disease of Oil Palm. Bugs of *Linchus lobuliger, Linchus spurcus* and *Linchus lethifer* are vectors of Sudden wilt disease.

Main Hosts Oil Palm (*Elaeis guineensis*) and coconut (*Cocos nucifera*)

Source: by M. L. Elliott

E. guineensis affected by sudden wilt in late stages of disease surrounded by healthy palms. Dead leaves have formed skirt around trunk

Identification The disease starts with browning of the older leaves and progresses to the younger ones, starting at the tips. Freshly opened inflorescences are black while older ones gradually rust. Young fruits turn brown, shrink, rot and fall. Roots and spears rot and the plant finally dies with crown rot secondarily infected by opportunistic bacteria and fungi. Death often occurs within 2 to 3 months of symptoms onset, but this may depend on the palm variety. This disease is not normally observed until *Cocos nucifera* is 3 to 4 years old or *Elaeis guineensis* is 2 years old. The symptom may be confused with lethal yellowing of *Cocos nucifera* and red ring disease of *Cocos nucifera* and *Elaeis guineensis.*

Source: UNIVERSIDAD NACIONAL AGRARIA DE LA SELVAUNIVERSIDAD NACIONAL AGRARIA DE LA SELVA

Symptom of Sudden wilt disease on coconut palm

Source: by M. L. Elliott

Chlorosis and necrosis of leaf tip of older leaf of *E. guineensis* affected by sudden wilt disease

Distribution Widely distributed in Aruba, British Virgin Islands, Costa Rica, Cuba, Dominican Republic, Nicaragua, Trinidad and Tobago (Central America and Caribbean region); Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, Venezuela (South America region).

Threat Serious threat to coconut and oil palm industries in Malaysia. Currently there are no effective treatments of *Phytomonas* plant diseases.

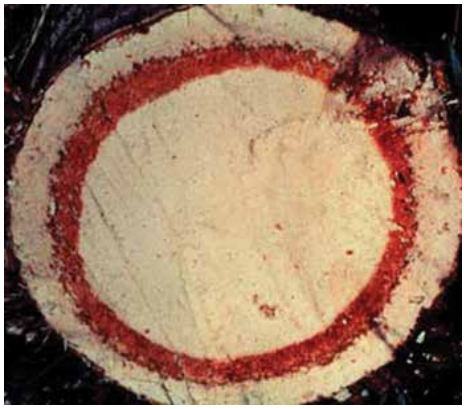
Quarantine Quarantine pest for Asia, Africa, North America, Europe and Oceania region. In Malaysia, it is listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia | Not Present

Red Ring Disease of Palm

Bursaphelenchus cocophilus (Ξ Rhadinaphelenchus cocophilus)

Bursaphelenchus cocophilus causes red ring disease of palms. Red ring disease can infect several species of tropical palms, but is most common in oil and coconut palms. The red ring nematode parasitizes the palm weevil *Rhynchophorus palmarum* L., which is attracted to fresh trunk wounds and acts as a vector for B. *cocophilus* to uninfected trees.



Source: : Society of Nematologists , University of Hamburg, Germany

The telltale red ring seen here in a cross-section of a palm indicates that this particular tree is infested by red ring nematode

Main Hosts Palmae: Coconut (*Cocos nucifera*), Oil palm (*Elaeis guineensis)*, Date palm (*Phoenix dactylifera)*

Identification The disease is not recognizable externally in its very early stages. The most characteristic symptoms are the internal lesions. In a cross-section of the stem, they appear as an orange to brick-red coloured ring, 2 to 4 cm wide, and at a distance of 3 to 5 cm in from the periphery. Occasionally, in some older trees, the entire central cylinder of the stem becomes one solid block of red. In external symptoms, already-established leaves become short and deformed and turn yellow-bronze, then deep reddish-brown. The colour change usually begins at the tip of each leaf and starts in the older leaves before moving to the younger ones. As the leaves change colour and dry up, they wilt and die. *B. cocophilus* is a relatively long, vermiform nematode with long tapering tails, about 1 mm for both females and males, but are also very thick. The vulva is positioned one-third body length from tail tip. Stylets are small, 11 to 13 µm long and are often obscure.

Source:: University of Florida

Yellowing, bronzing, and death of progressively younger leaves

Source:: R. M. Giblin-Davis, University of Florida

Cross-section through *Cocos nucifera* trunk exhibiting typical ring discoloration pattern near the outside edge of the trunk

Distribution At present, red ring disease has a restricted distribution in tropical America and has only been reported from the West Indies (Trinidad, Tobago, Grenada and St Vincent) and from Latin America (Venezuela, Guyana, Surinam, French Guyana, Colombia, Ecuador, Peru, Mexico, Brazil, Panama, Nicaragua, Costa Rica, Honduras, Belize and El Salvador).

Threat This nematode causes serious damage to coconut and oil palm. In Trinidad, red ring disease kills 35% of young coconut trees. In nearby Tobago, one plantation lost 80% of its coconut trees. Over a 10-year period in Venezuela, 35% of oil palms died from red ring disease. Considering that more than five million hectares of coconut and oil palms are grown, red ring disease is a serious threat to Malaysia.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

Status in Malaysia	Not Present

Khapra Beetle

Trogoderma granarium

Khapra beetle is one of the most destructive stored grain pests, and infestations can destroy the quality of grain and other commodities. Without food, diapausing larvae may survive about 9 months; with food, they may live for 6 years. In this state of very low metabolic activity, they are extremely resistant to the effects of contact insecticides or fumigants; complete disinfestation may thus be difficult.

Source:©S. Weingarten, University of Florida

Adult khapra beetle, *Trogoderma granarium*

Main Hosts Stored grain (rice, maize, wheat, groundnut).

Identification Eggs initially milky-white, later pale-yellowish; typically cylindrical, 0.7 mm long and 0.25 mm broad; one end rounded, the other more pointed and bearing a number of spine-like projections, broader at the base and tapering distally. A characteristic feature of the larva is the presence of two kinds of body hairs: simple hairs, in which the shaft bears many small, stiff, upwardly directed processes; and barbed hairs, in which the shaft is constricted at regular intervals, and in which the apex consists of a barbed head.

Source: Ministry of Agriculture of Australia

Adult, larva and larval skins of *T. granarium* on wheat grains

Source:Cornel Adler, Julius Kühn-Institut, (JKI) Germany

Young larvae of *T. granarium*

Source:Yu.B. Mordkovich and E.A. Sokolov,All-Russian Plant Quarantine Centre, Bykovo Russia

Mature larvae of *T. granarium*

Distribution Asia - India, Afghanistan, Bangladesh, Iran, Iraq, Israel, Turki, Yemen, Lebanon, Sri Lanka, Syria, Myanmar, Pakistan, Republic of Korea, Saudi Arabia and Lebanon.
Africa - Burkina Faso, Egypt, Morocco, Sudan, Tunisia, Zambia, Zimbabwe, Niger, Nigeria, Senegal, Somalia, Zanzibar, Libya, Mali, Mauritania and Algeria.
Europe - Cyprus, Former USSR, Spain and Switzerland.

Threat Fourth instar or older larvae feed on whole grain. Reduced grain seed viability and loss of stored grain seeds can threaten large-scale agriculture and international trade, hence the significant focus by multiple countries on limiting its expansion.

Quarantine Restriction on importation of plants from countries where Khapra beetle is present as in Ninth Schedule under Plant Quarantine Act 1976.

Status in Malaysia **Not Present**

Frosty Pod Rot of Cocoa

Moniliophthora roreri

The disease was first reported in Colombia in 1917 and has spread to Ecuador, Western Venezuela, Panama, Costa Rica, Peru, Nicaragua, Guatemala, Belize and Mexico.

Source: Harry C. Evans/CABI Bioscience

Internal symptoms in a cocoa pod with no external symptoms apart from irregular, premature ripening

Main Hosts Cocoa (*Theobroma cacao*)

Identification Symptoms appear only on pods, and their nature depends upon the age of the pods when infected. Pods that are infected show slightly chlorotic swellings and sometimes distortion, followed by general necrosis. The necrosis also spreads internally, particularly to the endocarp and placenta. Pods that are infected after 3 months of age may show no external symptoms, or only limited necrosis. Infected pods are noticeably heavier than healthy ones. Fungus produces spores that are spread naturally by wind, water and movement of the infected pods. Spores can survive up to 9 months on any carrier (tools, shoes, clothes, shipping container, vehicle and equipment).

Source: Harry C. Evans/CABI Bioscience

Irregular, chocolate-brown necrosis appearing on swollen or distorted cocoa pod 6-8 weeks after infection

Source: Harry C. Evans/CABI Bioscience

Brown, powdery spores developing on pseudostroma on maturing cocoa pod; infected 2-3 months previously

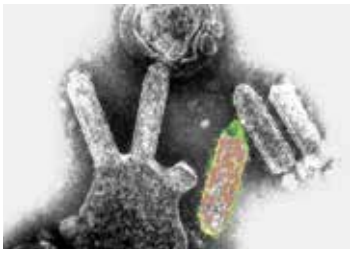
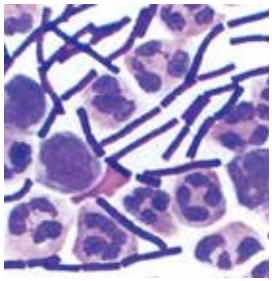
Distribution North America, South America, Africa, Central America, and Caribbean.

Threat Frosty pod rot disease has been reported to be twiced as destructive as black pod rot disease. Average pod rot losses is over 30% but can exceed 90% under favorable conditions.

Quarantine Listed as dangerous pest in Fourth Schedule of Plant Quarantine Act 1976.

II. FACTSHEET OF INVASIVE ALIEN SPECIES IN WILDLIFE AND ANIMAL TRANSMITTED DISEASE



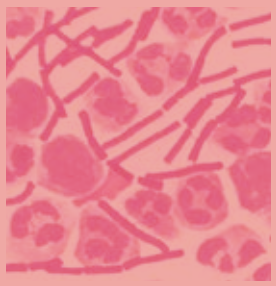


















Status in Malaysia	Present

Foot and Mouth Disease (FMD)

Picornavirus
Family: Picornaviridae; Genus: *Aphthovirus*

There are seven serotypes of FMD virus (FMDV), namely O, A, C, SAT 1, SAT 2, SAT 3, and Asia 1, that infect cloven hoofed animals. Cattle are usually the main reservoir for FMD viruses, though pigs spread the disease fastest. The virus can be preserved by refrigeration and freezing. Progressively inactivated by temperatures above 50°C. Heating meat to a minimum core temperature of 70°C for at least 30 minutes inactivates the virus.

Source: United States Department of Agriculture

Lesions on the gum

Identification Early signs include fever, reduction in milk production for 2–3 days, drooling and a reluctance to move. Blisters appear on the mouth or snout, on the tongue, lips, between the hooves and on the feet. The blisters rupture to expose raw, painful tissue. The severity of clinical signs varies with the strain of virus, exposure dose, age and breed of animal, host species, and degree of host immunity. Signs can range from mild or in apparent to severe. Morbidity may approach 100%. Mortality in general is low in adult animals (<5%) but higher in young calves, lambs and piglets (20% or higher). Recovery in uncomplicated cases is usually about two weeks.

Source: Department Of Veterinary Services Malaysia

Lesion on the foot

Source: Department Of Veterinary Services Malaysia

Excessive salivation in cattle

Source: Department Of Veterinary Services Malaysia

Sloughing of FMD lesion on tongue

Distribution FMD is endemic in parts of Asia, Africa, Middle East and South America (sporadic outbreaks in free areas). The outbreak in the UK and parts of Europe in 2001 has been disastrous, with millions of animals destroyed and billions of dollar revenue lost.

Threat The disease could cause severe damage to our meat, dairy and livestock industries. As well as having a devastating impact on individual farmers and the rural community.

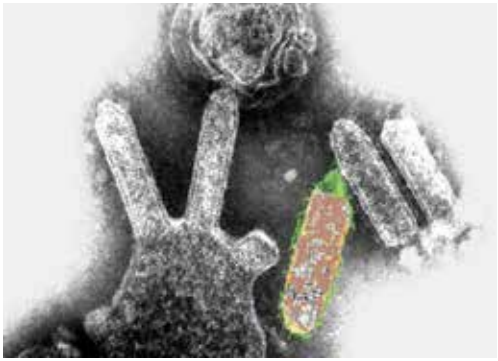
Control Measures Live animals, dairy foods, animal hides, meat and meat products are only allowed under Department of Veterinary Services approval based on import regulation.

Status in Malaysia	Present

Rabies

Rabies Virus and Australian Bat *(Lyssavirus)*

Rabies is a zoonotic, fatal and progressive neurological infection caused by rabies virus of the genus *Lyssavirus* and family *Rhabdoviridae*. Rabies is aneurological disease of mammals that is almost invariably fatal once the clinical signs develop. All mammals are susceptible to infection. In Malaysia, dogs are the main reservoir. In Latin America, vampire bats can transmit the disease. Common form of exposure is virus-laden saliva from a rabid animal introduced through a bite or scratch.



Source : http://www.scienceimage.csiro.au/

Colored transmission electron micrograph of Australian bat lyssavirus. The bullet-like objects are the virions, and some of them are budding off from a cell.

Identification Incubation period from virus inoculation is 3 weeks to 3 months. Pain and paresthesia at the exposure site, progresses rapidly from a nonspecific, prodromal phase with fever and vague symptoms to an acute progressive encephalomyelitis usually fatal.

Source: Centers for Disease Control & Preven on's Public Health Image Library (PHIL)

A dog with rabies in the paralytic (post-furious) stage

Source: Department Of Veterinary Services Malaysia

Mass anti-rabies vaccination program

Source: Department Of Veterinary Services Malaysia

Awareness campaign to the community

Distribution Found in all continents except Antarctica.

Threat Causes fatality once symptoms present. High mortality and morbidity on animal and human.

Quarantine Importation of dogs and cats are only allowed under Department of Veterinary Services approval based on import regulation. Refer to Department of Veterinary Services website for further information about Regulation for the importation of dogs and cats into Malaysia.

Control Measures Rabies in domesticated animals can be prevented by vaccination and avoidance of contact with rabid wild animals. Stray animals should also be controlled. Asymptomatic dogs, cats or ferrets that have bitten humans (with no history of exposure to rabies) are currently observed for 10 days; if the animal develops signs of rabies during this time, it is euthanized and tested for rabies. Bites or other exposures should be reported immediately.

Status in Malaysia	Present

Red Eared Slider

Trachemys scripta elegans

Source: : PAN XUNBIN/SHUTTERSTOCK

Red eared slider

The red-eared slider (*Trachemys scripta elegans*) has been the most popular turtle in the pet trade with more than 52 million individuals exported from the United States to foreign markets between 1989 and 1997. Despite the vast worldwide occurrence of the sliders little is known of their impact on indigenous ecosystems. It is clearly that research and education on the dangers of releasing pet turtles into the wild are needed. Their omnivorous diet and ability to adapt to various habitats gives them great potential for impacting indigenous habitats.

Identification Adult red-eared slider is a medium (carapace length: 150 - 350 mm) freshwater turtle characterised by prominent yellow to red patches on each side of the head, typically red on *T. scripta elegans*. Carapace and skin are olive to brown with yellow stripes or spots; males are usually smaller than females and have a long, thick tail. The eggs are ovoid in shape, 31 to 43 millimeters long, 19 to 26 millimeters wide and weigh 6.1 to 15.4 grams.

Source: https://flic.kr/p/SeBKGy

Red band on the head can be use to identify this species.

Sourcehttps://flic.kr/p/Swfe7h:

Red eared slider swimming.

Source:https://flic.kr/p/bBNPyT

A group of red eared slider basking under the sun.

Distribution Widely distributed in Asia (Bahrain, Cambodia, China, Malaysia, Indonesia, Israel, Japan, Korea DPR, Republic of Korea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam), Africa (South Africa and Canary Island), North America, Central America, Caribbean, South America, Europe and Oceania.

Threat Their omnivorous diet and ability to adapt to various habitats, gives them great potential for impacting indigenous habitats.

Quarantine Control the introduction into the country – Wildlife Conservation Act 2010 (Fifth Schedule). No permit allowed for importation of the species.

Status in Malaysia	Present

Bufo Toad

Rhinella marina (synonym: *Bufo marinus*)

Source: :http://www.iucnredlist.org/details/41065/0

Adult Bufo Toad

Bufo toads were introduced to many countries as biological control agents for various insect pests of sugarcane and other crops. Unfortunately, after a certain time, these toads turn out to be pests as well. They will feed on almost any terrestrial animal and compete with native amphibians for food and breeding habitats. Their toxic secretions are known to cause illness and death in domestic animals that come into contact with them, such as dogs and cats, and wildlife, such as snakes and lizards. Human fatalities have been recorded following ingestion of the eggs or adults.

Identification Bufo toads are heavily built with short legs. They can sometimes grow up to 30 cm long, with 20 cm not uncommon for females and average of 12-15 cm in many regions. Males are slightly smaller. Fingers lack webbing, but the toes are heavily webbed. Adults have a rough, warty skin, coloured tan, brown or dark brown, dull green or black. The tympanum is distinct, about one half to two thirds the size of the eye. Venom glands are aggregated together to form large and distinctive parotoid glands, found above each shoulder.

Source: https://flic.kr/p/gnb4d

Side profile of Bufo Toad.

Source:https://flic.kr/p/5jnFwt

Bufo toad camouflaging on the forest floor.

Source: https://flic.kr/p/aM9ESp

Back of Bufo Toad

Distribution Native in South America. Spread worldwide including in Malaysia as invasive alien species.

Threat Bufo toads affect the population of native python, monitor lizard. Act as predator to rats and mice. Toads consume both “harmful” and “beneficial” invertebrates. It can produce toxic which cause illness and death in both domestic and wild animals that come into contact with toads, such as dogs, cats, snakes and lizards.

Preventative measures The main controls on the spread of Bufo toads are quarantine checks, public awareness and response.

Status in Malaysia	Present

European Starling

Sturnus vulgaris

The European starling has been introduced globally, save in neotropic regions. The starling prefers lowland habitats and is an aggressive omnivore. This species cost hundreds of millions of dollars in agricultural damage each year and contribute to the decline of local native bird species through competition for resources and nesting spaces.

Source : https://flic.kr/p/FxcukD

European Starling

Identification A small bird approximately 21.5 cm long and weighing around 70 to 100 grams. Iridescent green glossed feathers cover the nape, breast and back of the bird, while the wings are black, sometimes with a green or purple veneer.

Distribution Native to Europe, Asia (Malaysia, Thailand, South Korea, Japan, China, Mongolia, India, Pakistan, Afghanistan, Kazakhstan, Iran, Iraq, Saudi Arabia, Egypt, Philippines and Lao) and North Africa.

Habitat : Prefer lowland habitats to more mountainous terrain. They are secondary cavity nesters, using extant cracks, crevices, and cavities created by other species. During breeding season the European starling requires holes for nesting and vegetation fields for feeding. The rest of the year it will utilise a wider range of habitats from moorland to salt marshes. European starlings are highly adaptable when selecting nest hollows, e.g. fence posts, roof linings under guttering (there has been an observation of a starling nest in the wool of a live sheep).

Source: https://flic.kr/p/DHfCKb

A group of European Starling

Source: https://flic.kr/p/VUvRnY

Juvenile European Starling

Source: https://flic.kr/p/VUvRnY

European Starling eating.

Threat Cause damage to agricultural crops. When significant numbers are present starling flocks may descend on fruit and grain crop fields to forage, causing massive damage and can have a heavy economic effect. European starlings are extremely aggressive omnivores, and will compete with native fauna for food. Open bill probing is most commonly used for ground invertebrates, which is their preferred food. Hence this provides the European starling with an evolutionary advantage over frugivores. Fruit damage is often found to be caused by a higher proportion of juveniles, which have underdeveloped probing skills. Usurping nests by contamination (as well as physical competition) is also a major problem (e.g. native parrots use little, if any, bedding, whereas starlings will rapidly fill and contaminate tree hollows). European starlings are also a public nuisance and can damage infrastructures, roof linings, etc. and negatively affect aesthetics.

Quarantine Control the introduction into the country – Wildlife Conservation Act 2010 (Fifth Schedule). No permit allowed for importation of the species.

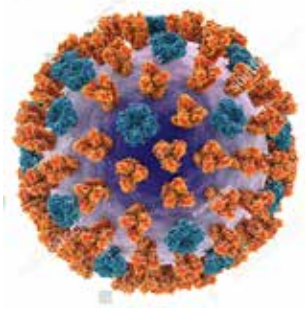
Control Measures Mechanical control by trapping and shooting.

Status in Malaysia	Present

Highly Pathogenic Avian Influenza (HPAI)

Highly Pathogenic Avian Influenza Virus (Orthomyxoviridae/Influenza Virus A)

The emerging and re-emerging of avian influenza viruses infection in the world which infected wide range of hosts involving avian, mammals include humans making this disease highly dynamic and difficult to eradicate. Together with its segmented genomic features making this virus highly dynamic to reassert and form new subtypes and strains.



Source: Kateryna Kon

Influenza virus

Identification The causal pathogen Influenza virus A from orthomyxoviridae is known to naturally affect birds with natural reservoir is the aquatic birds/migratory birds. The segmented genomic features of avian influenza viruses making it highly dynamic virus. Presence of 8 genes with two surface glycoproteins, i.e HA (H1 to H16) and NA (N1 to N9), will form potential 144 subtypes with equivalent potential to become highly pathogenic. Wide range of affected hosts from avian, mammals and humans, AIV capability to cross species barrier and established on this host making the host species viruses e.g Human influenza virus (HIV) (H3N2, H1N1, H2N2), swine influenza virus (SIV) (H3N2, H2N2, H1N1), equine influenza virus (EIV) (H7N7, H3N2). This virus is easily spread through droplets and faeces and will survive longer in the lower temperature. The highly pathogenic influenza virus can cause high mortality to chickens and humans with signs of haemorhages and respiratory symptoms. The incubation period varies from very acute (3 to 5 days) and up to 2 weeks.

Source: https://systematicreviewsjournal.biomedcentral.com/

Global distribution of avian influenza virus outbreaks

Distribution Worldwide and inhabit the northern hemisphere. The virus can survive cold temperature and live longer in frozen condition and will proliferate in warm condition. Carrier animal (migratory birds) will carry the viruses across continent and spread the virus to the terrestrial birds.

Source:http://www.oklahomafarmreport.com/

Severe economic losses could happen due to HPAI outbreak

Threat The disease poses major economic loss to poultry industry and caused human mortality. Vaccine does not cross protect and goal standard to eradicate the virus is through stamping-out which is very costly. High mortality and morbidity on animal and human.

Control Measures Vaccine is not effective. Stamping out is the best or goal standard to eradicate the disease.

Source:https://www.dw.com/

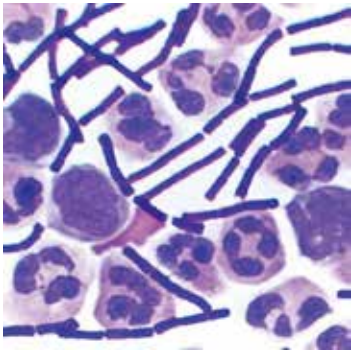
Stamping of infected birds and birds at risk.

Status in Malaysia	Not Present

Anthrax

Bacillus anthracis

Anthrax is primarily a disease of herbivorous animals, although all mammals, including humans, and some avian species can contract it. Mortality can be very high, especially in herbivores. The disease has world-wide distribution and is a zoonosis. Transmission by direct contact with infected animals, their carcasses or contaminated products



Source: http://www.infectionlandscapes.org/

Bacillus anthracis rods

Identification Present as cutaneous, gastro intestinal, pulmonary and severe form- meningitis depending on the route of exposure. Anthrax in humans generally not considered being contagious. Human to human transmission rarely occurs. Generally, animals (herbivores) acquire anthrax by ingestion of spores while grazing or browsing.

Source: http://civas.net/

A cow that has died from anthrax.

Source: NSW, DPI

A cow that has died from anthrax with blood discharge from nostrils

Source: https://www.sciencedirect.com/

Cutaneous anthrax in human

Distribution Distributed in sub-Saharan, Africa and Asia, agricultural regions of South and Central America, and southern and eastern Europe.

Threat It is a serious zoonosis, can be transmitted from animals to humans. It has high mortality and morbidity on human. It has economic impact on trade and environmental such as soil contamination and agriculture.

Control Measures Live animals, animal hides, meat and meat products are only allowed under Department of Veterinary Services approval based on import regulation.

Status in Malaysia	Not Present

West Nile Fever

West Nile Virus *(Flavivirus)*

Most commonly spread to people by infected mosquito bites. *Culex* mosquitos are common vectors which bites avian and mammalian species.

Source: Medicinenet.com

Mosquito bites

Identification

Febrile illness Fever with other symptoms such as headache, body aches, joint pains, vomiting, diarrhea, or rash. Recovers completely, but fatigue and weakness can last for weeks or months.

Severe illness Affecting the central nervous system such as encephalitis (inflammation of the brain) or meningitis (inflammation of the membranes that surround the brain and spinal cord).

Www.yavapas.us/

Culex mosquito

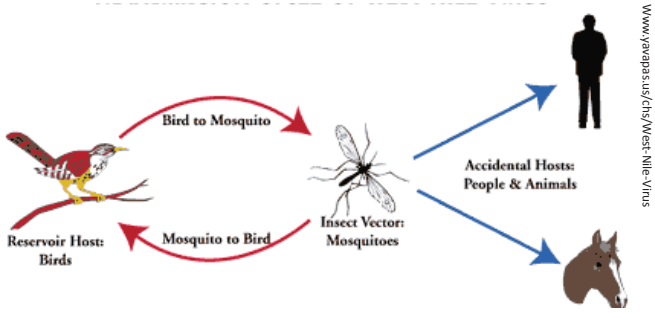
Distribution Africa, Asia, Australia, Middle East, Europe, Canada .

Threat About 1 out of 10 people who develop severe illness affecting the central nervous system die.

Www.yavapas.us/

Diffuse Maculopapular Rash associated with West Nile Virus Infection

Control Measures There is no human vaccine. The best method to reduce the risk of infections is avoiding mosquito bites. This may be done by eliminating standing pools of water, such as in tires and buckets.



Www.yavapas.us/chs/West-Nile-Virus

West Nile Virus transmission cycle

Status in Malaysia	Not Present

African Swine Fever

African Swine Fever Virus (*Asfivirus*) Family: Asfarviridae; Genus: *Asfivirus*.

African swine fever (ASF) is an infectious disease of domestic and wild pigs of all breeds and ages, caused by a virus that produces a range of syndromes. Soft ticks of the *Ornithodoros* genus, especially *O. moubata* and *O. erraticus*, have been shown to be both reservoirs and transmission vectors of ASF virus (ASFV). The virus remains viable for long periods in blood, faeces and tissues; especially infected, uncooked or undercooked pork products.

Source: viralzone.expasy.org

Asfarviridae virion

Identification Pigs are the only domestic animal species that is naturally infected by ASFV. The more virulent strains produce per acute or acute haemorrhagic disease characterised by high fever, loss of appetite, haemorrhages in the skin and internal organs, and death in 4–10 days, sometimes even before the first clinical signs are observed. Mortality rates may be as high as 100%. Less virulent strains produce mild clinical signs such as slight fever, reduced appetite and depression which can be readily confused with many other conditions in pigs and may not lead to suspicion of ASF. Low virulent, non-haem adsorbing strains occasionally produce mainly subclinical non-haemorrhagic infection and seroconversion, but some animals may develop discrete lesions in the lungs or on the skin in areas over bony protrusions and other areas subject to trauma. Animals which have recovered from either acute or chronic infections may become persistently infected, acting as virus carriers.

Source: https://www.pigprogress.net/

Petechiae in affected pig

Source: http://vetparaprofessional.blogspot.com/

Close-up of flushed/cyanotic skin

Source: http://www.fao.org/

Congested ocular mucosa

Distribution ASF epidemiology is complex with different epidemiological patterns of infection occurring in Africa and Europe. The disease is enzootic in most countries of Sub-Saharan Africa including Madagascar. In Europe, it has been reported and successfully eradicated from the Iberian Peninsula but continues to be found in Sardinia. In the 1970s, ASFV was present in the Caribbean (Haiti and the Dominican Republic) and one country in South America (Brazil) but was successfully eradicated. Most recently, it has appeared in the Caucasus (Georgia, Azerbaijan, and Armenia) and Russia.

Threat The disease could cause severe damage to swine industries. As well as having a devastating impact on individual farmers and the rural community. The disease could also affect the export activities.

Control Measures Live swine, pork and pork products are only allowed under Department of Veterinary Services approval based on import regulation.

Status in Malaysia | Not Present

Rift Valley Fever

Rift Valley Fever Virus (*Phlebovirus*)
Family: Bunyaviridae ; Genus: *Phlebovirus.*

Rift Valley fever (RVF) is a vector-borne disease of sheep, cattle and goats; peracute or acute zoonotic disease of domestic ruminants. The disease usually presents an epizootic form over large areas of a country following heavy rains and sustained flooding, and is characterised by high rates of abortion and neonatal mortality, primarily in sheep, goats and cattle. Humans are susceptible to RVFV and are infected through contact with infected animal material (body fluids or tissues) or through bites from infected mosquitoes.

Source: iPhoto: BORIS ROESSLER / DPA

RVF can be transmitted to humans by infected mosquitoes or close contact with contaminated animals

Identification The disease is characterised by abortion, neonatal mortality and liver damage. The disease is most severe in sheep, goats and cattle. Older non-pregnant animals, although susceptible to infection, are more resistant to clinical disease. There is considerable variation in the susceptibility to RVF of animals of different species. Camels usually have an inapparent infection with RVF virus (RVFV), but sudden mortality, neonatal mortality and abortion occurs and abortion rates can be as high as in cattle. In humans, RVF infections are usually inapparent or associated with a moderate to severe, nonfatal, influenza-like illness. A minority of patients may develop retinal lesions, encephalitis, or severe hepatic disease with haemorrhagic manifestations, which is generally fatal.

Source: PROF. COETZER, UNIVERSITY OF PRETORIA

Ewe aborting as a result of RVF

Source:PROF. COETZER, UNIVERSITY OF PRETORIA

Abortion resulting from RVF infection

Source:Food and Agriculture Organization of the United Nations. EMPRES-

Animals affected by RVF in lateral decumbency or dead

Distribution Sub-saharan regions of Africa, Egypt, Arabian Peninsular (Yaman, Saudi Arabia), Madagascar and Mauritania.

Threat The disease could cause severe damage to ruminant industries as well as having serious human infections in laboratory workers. The disease could also affect the export activities.

Control Measures Live animals are only allowed under Department of Veterinary Services approval based on import regulation.

Status in Malaysia	Not Present

Ovine Rinderpest (Sheep and Goats Plague)

Peste des Petits Ruminants Virus (*Morbilivirus*) Family: Paramyxoviridae ; Genus: *Morbillivirus*

Source: : http://www.fao.org/

Purulent eye and nose discharges

Peste des petits ruminants (PPRV) represent one of the most economically important animal diseases in areas that rely on small ruminants. The disease affects mainly sheep and goats and occasionally wild small ruminants. Based on the fact that PPR has been reported on a few occasions in camels, cattle and buffaloes, those animal species are considered to be susceptible although their potential role in the circulation of PPRV has not been formally established. Infected animals present clinical signs similar to those historically seen with rinderpest in cattle, although the two diseases are caused by distinct virus species.

Identification PPRV is an acute viral disease of small ruminants characterised by pyrexia up to 41°C that can last for 3–5 days; the animals become depressed, anorexic and develop a dry muzzle. Serous oculonasal discharges become progressively mucopurulent and, if death does not ensue, persist for around 14 days. A watery blood stained diarrhoea is common in the later stage. Pneumonia, coughing, pleural rales and abdominal breathing also occur. The morbidity rate can be up to 100% with very high case fatality in severe cases. PPRV is transmitted mainly by aerosols between animals living in close contact. The virus survives for long periods in chilled and frozen tissues.

Source: http://www.fao.org/

Inflamed (reddened) eye membranes

Source: http://www.fao.org/

Nodular lesions around the mouth

Source: http://www.fao.org/

Signs of diarrhoea

Distribution PPRV was first described in Côte d'Ivoire, but it occurs in most African countries from North Africa to Tanzania, and in nearly all Middle Eastern countries up to Turkey. PPRV is also wide-spread in countries from central Asia to south and south-east Asia. Recent incursions into China (Tibet) and Morocco have caused serious disease outbreaks and disease has been reported to be moving southwards in East Africa.

Threat The disease could cause severe damage to small ruminant industries. The disease could also affect the export activities.

Country Measures Live animals are only allowed under Department of Veterinary Services approval based on import regulation.

Status in Malaysia	Not Present

Mad Cow Disease

Bovine spongiform encephalopathy (BSE) (Prion)

A fatal neurological disease of adult cattle caused by transmissible prion disease.

Source: https://www.thelocal.fr/

BSE in dairy cattle

Identification BSE is not contagious and exists in two types - classical and atypical. Classical BSE develops as a result of foodborne exposure to prions via contaminated animal-source proteins (meat and bone meal [MBM]) in cattle rations. Horizontal transmission is not a significant source of new BSE infections. Calves born to infected cows are at greater risk of acquiring BSE than calves born to non-infected cows; however, this mode of transmission is of minor importance relative to infections acquired through contaminated feed sources. BSE is not transmitted horizontally by contact or aerosols. There is no sex or breed predisposition. In the UK, clinical disease was more common in dairy cows, probably because they were more likely to be fed animal-source protein supplements. Most cases are diagnosed in cattle 3–6 year old. The incubation period after exposure is ~2–8 year, and animals as young as 22 months have been diagnosed with BSE. Atypical BSE is different, and it generally occurs in older cattle, usually 8 years of age or greater. Atypical BSE cases have been described from countries with no apparent classic BSE epidemic. The incidence rates do not follow the trends observed for classical BSE. Together, these findings led to the hypothesis that atypical BSE results from spontaneous prion protein misfolding and is not related to ingestion of prion-contaminated feed. However, the mechanisms that induce the spontaneous prion formation remain obscure. It has been postulated that atypical BSE was at the origin of the BSE epidemic in the UK.

Source:https://infogram.com/

Depression in BSE cattle

Source: http://thenewsnigeria.com.ng/

Weight loss in BSE cattle

Distribution The disease was first diagnosed in the United Kingdom (UK) in 1986 and subsequently occurs in Europe, Japan, Canada and the United States. As of May 2018, 48 countries has been recognised as having a **negligible BSE risk**; and the People's Republic of China with the exclusion of Hong Kong and Macau, and Northern Ireland and Scotland in United Kingdom has been recognised as having a zone with a **negligible BSE risk** in accordance with Chapter 11.4. of the OIE *Terrestrial Animal Health Code.* In addition, 5 countries has been recognised as having a **controlled BSE risk**; and United Kingdom has been recognised as having a zone consisting of England and Wales with a **controlled BSE risk**.

Threat The disease can create a major economic impact to the cattle industry. The scale of the BSE epidemic and the cost to control the outbreak are unpredictable. Human can be infected when consume BSE contaminated cattle products and cause degenerative brain disease called variant Creutzfeldt-Jakob disease (vCJD). Currently, there is no treatment or vaccine for the disease. High mortality and morbidity on animal and human

Control Measures In Malaysia, BSE has never been reported in cattle either with clinical cases or through diagnostic test. Under the Animals Act 1953, BSE is listed as one of a reportable diseases. Banned use of ruminant protein (meat and bone meal [MBM]) in animal feed and only allow importation of cattle and meat from negligible BSE countries. Conduct targeted surveillance of occurrences of clinical neurological disease.

III. FACTSHEET OF INVASIVE ALIEN SPECIES IN FISHERIES AND MARINE SECTOR





















Status in Malaysia	Present

Marbled Crayfish / Marmorkrebs

Procambarus fallax forma *virginalis*

Order : Decapoda ; Family : Cambaridae

Source: facebook Adib Faisal Yaacob

Procambarus fallax forma *virginalis*

Marbled crayfish (English) or Marmorkrebs (German) was first discovered in the German pet trade in the mid-1990s, when aquarium enthusiasts reported on an all-female crayfish species that reproduces without males. Due to its characteristic and conspicuous colour pattern it became quickly known as `Marmorkrebs´ in German, which translates into English as 'marbled crayfish'. They are one of the most widely distributed species of crayfish in the international pet trade. In Madagascar, Marmorkrebs are harvested for human consumption and were sold in markets as cheap source of protein.

Distribution *P. virginalis* was originated from Madagasar and have been introduced into natural ecosystems on three continents. They have been found in the wild in the Czech Republic, Germany, Italy, the Netherlands, Sweden, Hungary, Slovakia, Ukraine, Madagascar, and Japan, probably through release or escape from aquaria. They are readily exist and available in Malaysia through online ornamental pet trade.

Identification The Marbled crayfish is a medium sized crayfish with a distinct, appealing marbled colour pattern and small chelae. The total length can be up to 13 cm, but is more often less than 10 cm. They exist only as females. Rostrum with moderately elevated and slightly thickened margins, tapering to a triangle acumen. Rostral shoulders at the base of the acumen either with a small marginal tubercle (in laboratory specimens and specimens from Madagascar) or a prominent spine (in free-living specimens from Germany). Acumen tip slightly rounded (in laboratory specimens) or with an acute spine (in free-living specimens from Germany). Median carina absent. The chelae are relatively small, being two times shorter than the carapace length. The palm (propodus) is elongated and the movable finger (dactyl) is only slightly longer than the medial (inner) margin of the palm. Dorsal surface of palm weakly granulated; ventral side with fewer punctuations. Medial (inner) margin of the palm with small tubercles. Ventral side with a symmetrical, bell-shaped *annulus ventralis* (seminal receptacle) with an s-shaped sinus, located between the bases of the 4th and 5th walking leg pairs.

Threat Marbled crayfish (Marmorkrebs) have caused concern as a potential invasive species because only a single individual is needed to establish a new population, and they can reproduce at high rates. The major pathway for Marmorkrebs introductions is the deliberate release of aquarium specimens. Its appealing colouration, undemanding nature and exceptional reproduction mode makes the Marmorkrebs attractive to aquarium hobbyists. However, parthenogenesis permits a high reproductive potential and Marmorkrebs can overpopulate an aquarium quickly. Aquarium hobbyists are likely to want to offload excess stock, either to other aquarium hobbyists or to the wild. This makes the risk of release resulting in a reproducing population considerably greater than for sexually reproducing crayfish species.

Quarantine In Malaysia, introduction of any new fish and marine species required special written approval (Import Risk Assessment – IRA) from Director-General of Fisheries Malaysia and importation of any species are mandatorily shall comply with rules and regulation stipulated under Fisheries Act 1985 and MAQIS Act 2011.

Status in Malaysia	Present

Red claw crayfish / Australian red claw crayfish

Cherax quadricarinatus

Order : Decapoda ; Family : Parastacidae

Source: uniprot.org

Cherax quadricarinatus

The red claw crayfish (*Cherax quadricarinatus)* is a species native to river catchments in northern Australia and south-eastern Papua New Guinea. It is a non-burrowing and physically robust species that grows relatively quickly in a wide range of environments The broad tolerance to environmental factors and attractive colours makes the species ideal for both aquaculture and aquarium industry and translocated to various parts of the world. In Malaysia, the redclaw is locally known as freshwater lobster due to its lobster-like appearance and habitat.

Source: Source: FRI Glami Lemi, 2018

Established population and potential impact of invasion in Sungai Perai, Pulau Pinang

Identification Body: Carapace smooth with one pair of long post-orbital ridges forming two keels on anterior carapace; spines on shoulder of carapace behind cervical groove - one prominent. Dorsal surface of telson without spines, membranous over posterior half.
Rostrum: Long with prominent apex; proximal borders more or less parallel, raised and extending posteriorly as two keels; three pairs of short lateral spines; median carina absent.
Appendages: Chelipeds can be very long in adult males. Chelae smooth, straight with narrow cutting edges; inner margin of chelae propodus longer than dactylus; distal superior margin of propodus uncalcified in mature males and forming a bright red-orange patch (hence common English name); mat of setae along proximal cutting edges of chelae absent. Distinct spur on inferior margin of cheliped coxa. Base of antenna with a distinct prominent spine. Antennae may be longer than the total body length in adult males.
Length: Up to 35 cm of total length, seldom longer.
Colour: Blue, mottled with beige and red on joints and body, red patches laterally on abdominal segments.

Distribution *C. quadricarinatus* has established feral populations in locations within Australia and Oceania region, Southern Europe, Eastern and Southern Africa, the Carribean, the Middle east, Eastern and South East Asia.

Threat The red claw crayfish exhibits the general characteristic of successful crayfish invaders with wide dietary requirements and high reproductive potential. Crayfish species can be a threat to human health if they are consumed without proper cooking and handling. They are also known to be intermediate hosts for parasitic digean flatworms such as the lung flukes *Paragonimus* species and rickettsialike parasites which can be transmitted to vertebrates and linked to various diseases in humans. They can also act as disease vectors for harmful microbes such including *Vibrio cholerae, Vibrio mimicus, enterococcids,* and *Escherischia coli.*

Quarantine In Malaysia, introduction of any new fish and marine species required special written approval (Import Risk Assessment – IRA) from Director-General of Fisheries Malaysia and importation of any species are mandatorily shall comply with rules and regulation stipulated under Fisheries Act 1985 and MAQIS Act 2011.

Status in Malaysia	Present

Peacock Bass

Cichla spp.
Order : Perciformes ; Family : Cichlidae

Cichla spp.

Source: Fisheries Research Institute (FRI) Glami Lemi

Peacock bass is the common name for fishes of the genus Cichla, a large cichlids, diurnal and predatory freshwater fish native species from the Amazon, Orinoco basins, and Guiana rivers in tropical South America. In their native origin, they are important as food fish and considered as game fish. They were introduced worldwide outside their native range as aquarium fishes and some are released in the water bodies, popular to be game fishes.

Identification While other species are smaller, the speckled peacock bass, *Cichla temensis*, can grow up to 13 kg in weight and 1 m in length and regarded as the largest species of Cichlid. Taxonomic classification of peacock bass has validated 15 *Cichla* species, generally differ in colour pattern and range, but similar in proportions and most meristics. Extensive variations also cause problems in identification in some species, like the speckled peacock bass, *Cichla temensis*. Most *Cichla* species display a colour pattern of three wide vertical stripes on their bodies, sometimes with smaller intermediate bands with a grey, brown, yellow or green background. They also recognised with a spot on their tail fins resembling the eyes on a peacock's tail feathers, hence the origin of their common name given as 'peacock'. Many adult species (primarily males), develop a pronounced (nuchal) hump on their foreheads shortly before and during breeding season. Other physical traits are in great variation, depending on species, individual as well as developmental stage.

Distribution Naturally originated from the tropical South America, they are now introduced and known to be established in warm parts of North America and Asia, where they are identified as invasive species.

Threat Once established as an introduced species, they may become invasive and damaging the ecosystem due to their highly predatory behaviour and extensive feeding on smaller native fish. They grow to a large size and piscivorous in nature. Some species, such as *C. ocellaris* has been introduced worldwide as an ornamental aquarium species, but once escaped to the natural environment, they may posed negative impact upon ichthyofaunas and aquatic environments through the mechanisms of predation, competition and alteration of food webs.

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This species is listed in a Fisheries Regulations (Prohibition of Import and etc. for Fish) Amendment 2011, Fisheries Act 1985 as a prohibition species to import, sale, culture and keep in Malaysia.

Source: Fisheries Research Institute (FRI) Glami Lemi

Established invasive population of Peacock Bass in Tasik Raban, one of the lakes in Peninsular Malaysia

Status in Malaysia	Present

Pacific Oyster

Crassostrea gigas

Order : Ostreoida ; Family : Ostreidae

Source: sea-ex.com

Valve of the shell

C. gigas is a bivalve, epifaunal, suspension/filter feeder that cements itself to rocks and other hard substrata and feeds primarily on phytoplankton and protists. The shell of *Crassostrea gigas* varies widely with the environment where it is attached. Its large, rounded, radial folds are often extremely rough and sharp. The two valves of the shell are slightly different in size and shape, the right valve being moderately concave. Shell colour is variable, usually pale white or off-white. Mature specimens can vary from 80 mm to 400 mm long.

Identification *C. gigas* has an elongated rough shell, which can reach a 20-30 cm size. Although highly variable, the two valves are solid but unequal in size and shape. The left valve is slightly convex and the right valve is quite deep and cup shaped. One valve is usually cemented to hard substrata. Shells are sculpted with large irregular, rounded radial folds. Radial ribs are on both shells starting from the umbo. Usually whitish, they show purple streaks and spots. Its inner side is white. The adductor muscle scar is kidney shaped.

Source: sea-ex.com

Flesh of pacific oyster

Distribution Originating from the northeastern Asia, *C. gigas* is endemic to Japan, but has been introduced and translocated, mainly for aquaculture purposes, to a number of countries, almost worldwide. In North America, the species can be found from southeast Alaska to Baja California, USA whereas in European waters the species is cultured from Norway to Portugal as well as in the Mediterranean Sea. Biological characteristics make it suitable for a wide range of environmental conditions, although it is usually found in coastal and estuarine areas within its natural range.

Threat The Pacific oyster or *Crassostrea gigas* originating from the northwest Pacific and Sea of Japan, especially in warm temperate regions between 30°N - 48°N. This puts it in the category of invasive alien species should it be brought into Malaysian waters. The main threats caused by the introduction of this species into our waters is the ability of this species to directly or indirectly modify, create or destruct habitats. *C. gigas* is described as an ecosystem engineer. *C. gigas* prefers similar habitats to the native slipper oyster, *C. iredalei* and the green mussel, *Perna viridis* . Negative effects include displacement of native species by competition for food and space, altered benthicpelagic and food-web interactions, hybridization with local oyster species, and transfer of parasites, diseases and pests.

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Status in Malaysia	Present

Algae Suckermouth Catfish

Hypostomus plecostomus

Order : Siluriformes ; Family : Loricariidae

Source: tampabaycichlids.com

Hypostomus plecostomus

Loricariids are characterised by bodies that are depressed and covered in flexible bony plates. They have a ventral mouth with modified lips (known as a 'suckermouth') with papillae (small projections) on the lips, and in some taxa, barbels. The modified mouth allows the fish to feed, breathe, and attach to the substrate through suction. Respiration and suction can function simultaneously. Loricariids possess important evolutionary innovations of the jaws and cranial bones that assist with feeding. Unlike most other catfishes, the premaxillae of loricariids are highly mobile, and the lower jaws have evolved towards a medial position, with the specialized teeth pointed rostroventrally. The fish rotates its lower and upper jaws to scrape or rasp the substrate. Loricariids have also evolved several modifications of their digestive tracts, including an enlarged, vascularized stomach in *Hypostomus* sp. that functions as an accessory respiratory organ and is used to increase buoyancy for moving about in the water column. Members of the Hypostominae possess distinctive lunate pupils believed to provide greater visual acuity along the frontal-caudal axis.

Identification *H. plecostomus* grows to approximately 50 cm long over its native range, though aquarium specimens are typically smaller (less than 30 cm). The body of *H. plecostomus* is brown to olive-brown with darker spotted or vermiculated patterns, and, in some specimens, dark dorsal saddles. Fins are similarly coloured. The abdomen is pale cream with brown spots that may be irregularly joined to form a vermiculate pattern. There is no granular edge on snout. There is a strong spine at front of the dorsal, pectoral and pelvic fins. Pectoral fins are horizontal and have thick, toothed spines that are used in male-male competition and locomotion. The dorsal fin has 1 spine and 7-8 rays. The anal fin has 1 spine and 3-5 rays. The tail is cylindrical and not flattened. Large adult males possess thickened pectoral fins that turn reddish-pink, and gravid adult females appear thicker when viewed from above.

Distribution *Hypostomus* sp. is native to Central and South America. It has been introduced to 17 countries in the Americas, Asia and Europe.

Threat *H. plecostomus* is a very popular ornamental freshwater fish and have many life history traits that make them successful invaders: they are covered in armoured plates, possess broad environmental tolerances and the ability to colonise anthropogenically-disturbed habitats. Because of their rapid maturation, high densities and longevity, *Hypostomus* sp. can rapidly monopolise nutrient resources, alter food webs, increase turbidity and cause bank erosion through nest building, and physically inhibit other aquatic organisms.

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Status in Malaysia	Present

Asian Red Tail Catfish

Hemibagrus wyckioides

Order: Siluriformes ; Family: Bagridae

Source: Department of Fisheries Malaysia

Hemibagrus wyckioides

Hemibagrus wyckioides can be found in large upland rivers; common in areas with rocky bottoms and irregular depths. This fish do not undertake longitudinal migration, but reproduces locally and enters the flooded forest during high water in July-October. They feeds on insects, prawns, fish and crabs.

Identification This species is the largest Bagrid catfish in Asia. They can reach 80 kg and length 130 cm. The caudal fin is white in small specimens and becomes bright red when it gets bigger (about 15 cm SL). Adipose fin long (length of adipose-fin base 18.7-25.7% SL), with a gently-sloping anterior margin; dorsal spine poorly ossified and short (7.5-11.4% SL) without serrations on posterior edge; length of dorsal-fin base 16.3-18.3% SL; maxillary barbels reaching to at least middle of adipose fin base (230.1-297.0% HL). Head flat rather than conical; a short occipital process not close to basal bone of dorsal fin; no stripes on body. *H. wyckioides* may resemblance its congener, *H. wyckii* but the former lacks serrations on the dorsal fin spine. They also have a shorter dorsal fin base and shorter maxillary barbels. Both species are reared as aquarium fish and cultured as food fish.

Source: udon-news.com

Asian Red Tail Catfish in Thailand

Distribution This catfish species originate from the Mekong basin and reported from the Chao Phraya and Maekhlong basins in Thailand.

Threat Impact on threatened or endangered species. Natural community composition – (Competition (e.g. decline in native species, changes in native species communities, hybridisation). Their size, aggressiveness and predatory behaviour makes this fish a threat. In nature, red tails of 12 inches (30.5 cm) are strictly predatory with half of their diet consists of other fishes. They also ate crustecea, insects and even snakes.

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Status in Malaysia	Present

Red-striped Earth-eater

Geophagus surinamensis

Order: Perciformes ; Family: Cichlidae

Source: Fisheries Research Institute
Glarni Lemi, Department of Fisheries Malaysia

Geophagus surinamensis

Geophagus is a genus of cichlids that mainly live in the freshwaters of South America. Comprised of at least 28 recognised species, they are part of a group popularly known as 'eartheaters' and mostly feed by picking up mouthfuls of sand to sift out food items such as invertebrates, plant material and detritus. *G. surinamensis* it is often caught in the quiet zones of cascades, lives in mud and sand-bottomed canals. Maximum length 30 cm TL. Omnivorous, with a tendency towards herbivory, searches for food by digging into the substrate with its protractile mouth. Spawning takes place on a flat stone or in a hole dug in the sand. Parents generally take the eggs into their mouths until hatching occurs three days later. At night or when faced with danger, the alevins seeks shelter in the mother's mouth. Parents take care of their siblings for several weeks.

Identification *G. surinamensis* is a peaceful, relatively non-territorial cichlid, with beautiful, almost iridescent patterns of blue, green and red markings. As their common name suggests (earth-eater), they are ferocious diggers, foraging constantly for food in the substrate. They are well designed for this, with a long, sloping forehead and eyes placed high on their head.

Distribution South America: Saramacca and Suriname Rivers in Suriname; Marowijne River in Suriname and French Guiana.

Threat More research needs to be conducted on the potential environmental impacts of *G. surinamensis* on ecosystems and resource competition with sympatric fishes. Breeding behaviour, agonistic behaviour and territoriality needs to be investigated.

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Status in Malaysia	Present

Flowerhorn

Cichlasoma hybrid*

Order : Perciformes ; Family : Cichlidae

Source: 5th National Flowerhorn Show in Singapore

Cichlasoma hybrid

The Flowerhorns are also referred as Luohan and Kirin cichlids, developed by the ornamental fish industry in Malaysia during the 1990s. The parental taxa used to create them are all New World (neotropical) Chichlids and they are hybrid complex with many varieties. Some Flowerhorn varieties are marketed under variety of names; Red Dragon, Super Red Dragon, Rainbow Dragon, Blue Dragon and Kamfa or Kampa and the list continues as fish breeders reportedly experimenting. These ornamental aquarium fish are named after the distinctively shaped heads and their vivid colours, that is possibly came from the many crossbreeding experiments of *"Cichlasoma", Amphilophus* and *Paraneetroplus.*

* Note: *Flowerhorns are subjected to critism when placing this 'man-made' fish into fish taxa which reserved to the fish naturally occur in the wild. Loss of genetic materials also can happen.*

Cichlasoma hybrid

Identification Flowerhorns are known for their unique protruding heads and beautiful coloured scales. The formal term for the protuberance head is “nuchal hump” which is believed to bring ‘good luck’ to the owner. There are several ways by which breeders distinguish between male and female flowerhorns. Generally, the males are larger than the females, but there are some exceptions. Males have the kok, or the nuchal hump, on their foreheads. Males also usually have brighter and more vivid colors. For most breeds, the females have black dots on their dorsal fins, whereas males usually have longer anal and dorsal fins. Females tend to have an orange belly, especially when ready to breed. The mouth of the male is thicker and more pronounced than the female's. One sure way to determine the sex of flowerhorn is that grown female will lay eggs every month even without the male. However, majority or most of flowerhorn males are sterile and therefore can not reproduce.

Distribution The fish are popular among fish hobbyist in Asia and also kept in the US and Europe, but banned in Australia.

Threat The fish are aggressive, territorial and predatory by nature. Like many other chichlids, they can breed quickly, able to compete with native fish if released to the wild.

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Status in Malaysia	Present

Freshwater Stingray

Potamotrygon motoro

Order : Myliobatiformes (Stingrays) ; Family : Potamotrygonidae

Potamotrygon motoro, the Ocellate River Stingray can be found in freshwater rivers, with natural habitat range in Río de la Plata, Amazon, Mearim and Orinoco basins in tropical and subtropical South America. This species is one of the most popular species of freshwater stingrays, kept in aquarium and public aquaria.

Source: Department of Fisheries Malaysia 2017

Potamotrygon motoro

Identification *P. motoro* varies in appearance and morphology, over its large distribution range and a taxonomic review is expected. It can grow up to 50 cm disc width (DW), 1m in total length and 35kg in weight. The disc is almost circular with eyes raised from the dorsal surface. Dorsal is beige or brown in colour, with numerous yellow-orange spots with dark rings. Its exact colour varies by individual and location. Five primary types have been found in the Amazon Basin with a number of subtypes. Tail moderately thick and short, and may be shorter than the disc. Has 18 to 39 longitudinal rows of teeth in the upper jaw. Its colouring pattern distinguishes it clearly from other species of the genus.

Distribution Distribution includes Bolivia, Colombia, the Bolivarian Republic of Venezuela, Guyana, Suriname, Brazil, French Guiana, Ecuador, Peru, Paraguay, Uruguay and Argentina.

Threat All species of river stingray in the Parano-plata Basin have delicious meat and are harpooned by fishermen. Artisanal and commercial fishermen also catch some specimens on lines. The attractively patterned juveniles of this species are collected for the ornamental fish trade. It is known to be an extremely dangerous species, can cause death to humans. They can survive well in our freshwater tropical habitat.

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Status in Malaysia	Present

Paddlefish

Polyodon spathula (American paddlefish)

Order: Acipenseriformes ; Family: Polyodontidae

Source: Department of Fisheries Malaysia

American paddlefish

Fishes under the order Acipenseriformes also knowned as sturgeons, are represented by two extant families; Acipenseridae and Polyodontidae. The former are anadromous and inhabits freshwaters in Northen Hemisphere, while the latter are strictly freshwater species, known from China and the United States. Sturgeons are among the oldest living vertebrates, with fossil records dating back more than 150 million years. There are two living species from the family Polyodontidae; *Polyodon spathula* from United States and *Psephurus gladius* reported from China. The American paddlefish is plankton-feeding with a nonprotrusible mouth. While the Chinese paddlefish is piscivorous with a protrusible mouth.

Identification Characterised by long paddle-shaped snout, body lacking the large body scales (scutes) of the sturgeons. The skin of the American paddlefish is bare except for a few vestigial scales, the head is drawn out at the front into a flattened snout. There are two minute barbels on the snout of the adult paddlefish, which are highly visible in its larval (fry) stage. The function of the snout is not entirely clear, possibly being used to stir up the mud to release food items, although others suggest it is a sensory organ. The paddlefish has a large, toothless mouth on the underside of its head. The gill covers are large and triangular, with the apex to the rear, and are drawn out into a point. Gill rakers long and hundreds in *Polyodon,* but shorter and fewer in Psephurus.The caudal fin is heterocercal, like that of a shark, with the upper lobe longer than the lower lobe. The skeleton of the paddlefish is cartilaginous except for bone-like material found in the dentary (jaw) region. Maximum length may attained up to 3 m, observed in *Psephurus gladius*.

Distribution Intensive commercial culture of sturgeon for meat and caviar is currently taking place in several countries, including the U.S., France, Italy, Spain, Germany, Austria, Hungary, Belgium, the Russian Federation, China, and Uruguay. From the 25 species of sturgeon (Fam: Acipenseridae) and two species of paddlefish (Fam: Polyodontidae), several are the primary focus of intensive commercial culture. These include the North American white sturgeon (*Acipenser transmontanus*), Siberian sturgeon (*A. baeri*), Adriatic sturgeon (*A. naccarii*), Sevruga (or stellate) sturgeon (*A. stellatus*), Russian sturgeon (*A. gueldenstaedti*), beluga sturgeon (*Huso huso*), including the American paddlefish (*Polyodon spathula*).

Threat It was reported that diseases are not a problem in production of paddlefish in ponds or reservoirs because of low stocking densities. However in intensively cultured system such as raceways, among the diseases reported in paddlefish includes rostrum degenerative diseases caused by both Aeromonas/ columnaris disease bacteria, and "Ich" infections (*Ichthyophthirius multifilis*). Currently there is no report on viral diseases in cultured or wild paddlefish. In addition, possible impacts on local fish populations and the aquatic environment might include: competition with indigenous fish for food cover or spawning sites, the introduction of new parasites or exotic diseases and adverse effects on the environment through habitat degradation (e.g. effects on benthos, water turbidity changes due to feeding activity).

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Status in Malaysia	Present

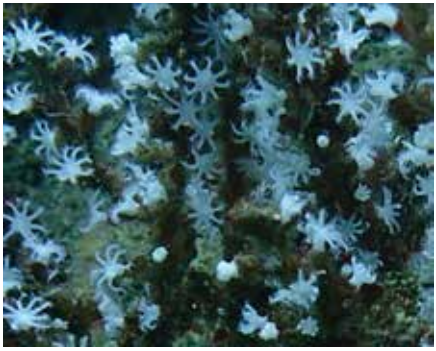
Snowflake Coral

Carijoa riisei

Carijoa riisei (Phylum Cnidaria, Subclass Octocoralia) is extremely capable of explosive growth which makes it an amazing competitor and allows it to outgrow its counterparts. In Marine Park waters, *C. riisei* inhabit at depth range of 10m - 20m and shaded area with low sunlight penetration. *C. riisei* has male, female and hermaphrodite colonies capable of single parent reproduction. Free-floating planktonic larvae will settle on hard substrate such as rock and concrete.

Source: Photo Library of IAS in Marine Park

Competition for area between snowflake coral and native species of *Tubastrea micrantha*



Source: Photo Library of IAS in Marine Park

Competition for area between snowflake coral and native species of *Tubastrea micrantha*

Identification *C. riisei* forms erect, branching colonies with flexible stems. Colonies form dense clusters of tangled, with prominent white polyps. Each tall axial polyp has many short lateral polyps. Creeping stolon running in all direction expedite the colonization of this species. *C. riisei* also is a fast linear branch growth rate that could exceed 1cm per week and colony branches as little as 2.5cm are already mature. It can grow about 10—25 cm height. It is a generalist filter-feeder.

Distribution Native species of Tropical Western Atlantic, Florida to Brazil and Carribean. Invasion of *C. riisei* in Pulau Payar Marine Park, Kedah was recorded in 2005.

Source: Photo Library of IAS in Marine Park

C. riisei clean-up activities

Source: Photo Library of IAS in Marine Park

C. riisei invasion kills native species of *T. micrantha*

Source: Photo Library of IAS in Marine Park

Removed *C. riisei* from Pulau Payar Marine Park

Threat *C. riisei* is a fast growing organism and could pose a serious threat to the native coral reefs. This species is in close symbiosis with the sponge *Desmapsamma anchorata* that carries potent cytotoxic compounds that strengthens the stolonal expansion of the *C. riisei* colony providing an additional advantage to compete for substrate and overgrow other octocorals. In Pulau Payar Marine Park, the competition for spaces are lead to reduce number of *Tubastrea micrantha* in certain area.

Control measure Department of Marine Park Malaysia (DMPM) has taken action to eradicate the spreading of *C. riisei* by organizing "Snowflake Clean-up Program" with the local stakeholders and other relevant agencies. Diving operators, Maritime Institute of Malaysia (MIMA), Royal Malaysian Navy and Fire and Rescue Department amongst others involve in these programs.

Quarantine In Malaysia, introduction of any new fish and marine species required special written approval (Import Risk Assessment – IRA) from Director General of Fisheries Malaysia and importation of any species are mandatorily shall comply with rules and regulation stipulated under Fisheries Act 1985 and MAQIS Act 2011. Discharging of ballast water from foreign going vessel are subject to International Convention for the Control and Management of Ship's Ballast Water and Sediment 2004 in Malaysia that has came into force on 8 September 2017.

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List of Abbreviations

IAS	Invasive Alien Species
RPW	Red Palm Weevil
PRSV-P	Papaya Ringspot Virus Type P
BDB	Blood Disease of Banana
TZC	Tetrazolium chloride
CCCVd	Coconut Cadang Cadang Viroid
CSSV	Cocoa Swollen Shoot Virus
SAPW	South American Palm Weevil
SALB	South American Leaf Blight
USSR	Union of Soviet Socialist Republics
OIE	World Organisation for Animal Health
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
ASF	African Swine Fever
ASFV	African Swine Fever Virus
RVF	Rift Valley Fever
RVFV	Rift Valley Fever Virus
PPRV	Peste des Petits Ruminants Virus
BSE	Bovine Spongiform Encephalopathy
vCJD	variant Creutzfeldt-Jakob Disease
MBM	Meat and Bone Meal
HL	Head Length
SL	Standard Length
IRA	Import Risk Assesment
MAQIS	Malaysian Quarantine and Inspection Service
MIMA	Maritime Institute of Malaysia