Introduced agricultural pests, plant and animals diseases and vectors in the Dutch Caribbean, with an "Alert species" list

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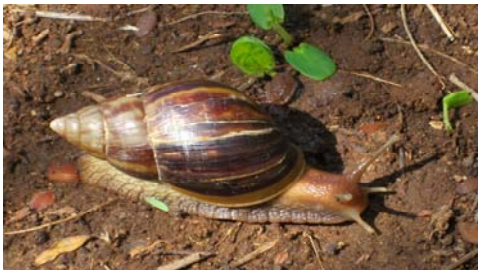

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Contents

Summary

We here review the introduced agricultural pests and animal and plant diseases and vectors for the Dutch Caribbean. In doing so we list and discuss a total of 47 exotic pests, diseases, parasites and pathogens established on one or more of the Dutch Caribbean islands. These include 2 species of voracious herbivorous snails, 7 species of millipedes, 8 species of invasive ants, and some 16 species of insects that infest plants. Most agricultural pests are not strongly host-specific and will typically also affect native plants and/or animals. This makes it very difficult to eradicate or control these species once established. Therefore, prevention and early eradication is key.

The most information on invasive alien pests is available for the leeward Dutch islands while the least is known for the windward Dutch islands. The principal means of entry is the importation of unsterilized soil and plant material through container shipment, import of ornamental plants and air traffic. The economic costs, both in terms of damages and control measures, as well as missed opportunities that these species cause, has not been estimated but certainly runs in the millions of dollars annually. By far the most economically costly invasive species is the yellow fever mosquito *Aedes aegypti*, a pest and disease vector closely associated with man. In a few cases, biological control and eradication has been successful.

Introduction of invasive pest species continues at a high rate in the Dutch Caribbean and preventive measures are urgently needed to limit future costs and risks in terms of economy and health.

Key recommendations are: a) to strongly restrict and control importation of ornamental plants, most of which can be propagated locally without risk of new introductions, b) restrict importation of unsterilized foodstuffs, c) practice tighter control and prophylactic fumigation of container shipments, d) continue strict veterinary controls on animal importations. To effectively implement such measures, will require greater awareness, supporting legislation, cooperation of customs agents and shippers and the presence of a biosecurity unit authorized and equipped to act on short notice.

Based on experiences in other Caribbean countries and existing trade patterns and taking into account which species could survive in an arid climate, it is possible to draw up a preliminary listing of “Alert” species for the Dutch Caribbean. Such a listing is a critical tool for effective prevention. Our preliminary Alert list discusses 21 species to be on the look-out for, most of which are insects and most of which can be expected to cause important damage to crops and/or nature, or both, if introduced.

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1. Introduction

Invasive alien species (IAS) are large and growing problem world-wide, including the Caribbean (Kairo *et al.* 2003). In their 2003 review, Kairo *et al.* listed some 552 exotic species for the wider Caribbean, among which 416 were already naturalized. For the Dutch Caribbean they only listed 5 exotics for Aruba, 4 for Bonaire, 41 for Curacao and 2 for St. Maarten. This listing was very incomplete and thus called for a more extensive assessment. Among invasive species, agricultural pests and animal and plant diseases and vectors (or "agricultural pests" for short) are often the economically most costly IAS. Such organisms may importantly affect commercially and economically important animals and crops but generally are not extremely host-specific and therefore affect native plants and animals as well. Generally little is has been documented on the extent of the exotics problem, the consequences of these introductions to terrestrial biodiversity in general, and on effective ways of limiting the various species.

Due to globalization the massive scale of global trade, plants and other products that may contain undesirable species can now come in from practically anywhere in the world. Invasive species which have not yet been documented but which could enter relatively easily and of which it is known that they would very likely have detrimental effects are identified as "Alert" species. EEA (2010) defines "alert list species" as species that are both a proven risk and also have a high probability of introduction. Key concepts here are "risk" and "probability of introduction". Therefore, risk assessment for species that could potentially be introduced is an essential tool. Several risk assessment tools have been developed and may be applicable to the situation in the Dutch Caribbean. One example developed and used in screening plant imports into Australia is referred to as a "weed risk-assessment (WRA) system and has recently been modified and applied successfully to the IAS problem in other Pacific Island systems (Daehler *et al.* 2004).

Nevertheless, it is very difficult to arrive at general criteria to predict possible invasiveness of a species. For now, the only predictor nearly everyone agrees on is history: a species that invades successfully in one place is likely to do it again elsewhere (Baskin 2002). A few examples can be given: the Corn snake is indigenous to North America and is found in temperate regions, it also occurs naturally in Florida which is subtropical. Nevertheless it is strange that such a snake apparently has managed to adapt itself to full tropical conditions, often reptiles from temperate regions need a cool period to reproduce. This example illustrates how difficult it sometimes is to foresee whether an introduced species will be problematic in a new environment or not. It is also known that some desert animals, which one would expect to adapt quite well to the arid Curaçao climate did not do very well in captivity. Such animals (for instance the desert tortoise *Gopherus agassizi*) are often adapted to very low levels of humidity; which at 74 % or more is much too high for them in Curaçao.

2. Objectives

In this report we compile information on exotic agricultural pests and plant and animal diseases and disease vectors that have been documented or registered for the Dutch Caribbean. In addition we provide a list of “Alert species” of “agricultural pests” for the Dutch Caribbean

This topic of IAS has been identified as a critically important issue for nature conservation in the Dutch Caribbean since the drafting of the first nature policy plan 2001-2005, and remains so today (Debrot et al. 2011). Particularly little is has been documented on the extent to which exotic species have invaded the islands in the Dutch Caribbean (Aruba, Bonaire, Curaçao, St. Eustatius, St. Maarten, Saba), the consequences to biodiversity in general, and whether possibilities exist to limit their effect in the future. In light of the fact that IAS remain an urgent concern, the Dutch Ministry of Economic Affairs, Agriculture and Innovation commissioned IMARES to provide an update and overview of exotic and invasive species for the Caribbean Netherlands.

In this report we briefly review the exotic agricultural pests and plant and animal diseases and disease vectors recorded for the Dutch Caribbean, identify key pathways of introduction and harmful risk species to be on the lookout for. We further discuss which if any measures could be undertaken to prevent the introduction and establishment of new exotics, or to minimize the impacts of those that have established themselves.

While the focus of this report is the Caribbean Netherlands (Bonaire, Saba, St. Eustatius), the need to include the other three island territories of the Dutch Caribbean (Aruba, Curacao and St. Maarten) in our review was dictated by:

- General interconnectedness of the Dutch Caribbean islands in terms of short geographical distances for motile marine species
- A centuries-long common history of exposure to exotic species and actual introductions
- The intensive and enduring economic ties and material and human traffic between the islands
- The fact that the IAS problem is truly a shared problem, with a high degree of overlap in species and issues.
- The fact that IAS are often costly to combat, optimally calling for a joint and coordinated approach based on a shared awareness.

3. Results

Our results are presented in two main sections. The first concerns documented species and the second concerns “Alert species” that could easily appear and can be expected to cause important damage to crops and/or nature, or both, if introduced. Appendix A provides an overview of the agricultural pests and plant and animal diseases and disease vectors present already documented for one or more areas of the Dutch Caribbean. A total of 47 species are listed. These include 2 species of voracious herbivorous snails, 7 species of millipedes, 8 species of invasive ants, and some 16 species of insects that infest plants. Appendix B provides our preliminary list of 21 “Alert species” which could easily appear or enter the Dutch Caribbean and pose a risk to economy and ecology. Most of these are insects.

4. Documented agricultural pests and plant and animals diseases and vectors

4.1 Molluscs

Giant (East) African Land Snail, *Achatina fulica*

The Giant African Land snail *Achatina fulica* also named *Lissachatina fulica* is present on St. Maarten. The Giant (East) African snail *Achatina fulica*, is the most damaging of the three, it is a serious pest, which is now present on several of the Lesser Antilles (Guadeloupe, Marie Galante, Martinique, St. Lucia, Dominica, Barbados, St Martin/St. Maarten, Anguilla and Antigua) and is also found in Trinidad (Tobago is still free of it), Venezuela (Martinez and Martinez 1997) and several other South American countries such as Colombia, Ecuador, Peru and Brazil. *A. fulica* may play a role in the transmission of the metastrongylus causative agents of eosinophilic meningoencephalitis (*Angiostrongulus cantonensis* and *A. costaricensis*) in humans. The parasites carried by the snail are usually passed to humans through the consumption of raw or improperly cooked snails. *A. fulica* is also a vector for the bacteria *Aeromonas hydrophila* and *Salmonella* and the plant pathogen *Phytophtora* especially *Phytophtora palmarum.*

Cuban garden snail, *Zachrysia provisoria*

Cuban garden snails: *Zachrysia provisoria* and the very similar *Zachrysia auricoma* are nowadays found on many Caribbean islands. *Zachrysia provisoria* is found on Saba. It is also found on St. Martin/St. Maarten (Bertrand 2001). A *Zachrysia* snail is also present in Curaçao, it was first found in the Dominguito area, around 2002, and has now spread to other areas nearby (Damacor, Toni Kounchi, Mahaai, Semikok). The snail in Curaçao is *Zachrysia provisoria* (identification by: Ad Hovestadt, in the Netherlands). *Zachrysia provisoria* is also found in the Groot Piscadera area, where it has been present for a few years now. These snails are very voracious and are a major horticultural pest. It is not yet known whether they can survive outside of gardens in the dry Curaçao climate and whether they will become a threat to native plants. Several snails were found that had apparently been killed and eaten by birds, very likely the mockingbird *Mimus gilvus*, which may be a natural predator to this invasive species.

4.2 Diplopods (Millipedes and Centipedes)

Millipeds and centipeds are one group of animals that have been extensively spread throughout the tropical zones of the world, principally by commerce. In this, particularly tropical islands have been vulnerable to invasion and large fractions of local faunas on small tropical islands are generally introduced species (Shelly and Lehtinen 1999; Shelley *et al.* 2005). Not surprisingly, several species (total = 8) of invasive millipeds and centipeds have already been identified for the Dutch Caribbean and the BES islands (Appendix A).

The largest number of invasive millipeds have been documented for Saba, which, for this group, so far is the most intensively studied of the Dutch Caribbean islands. The following species have been documented: *Asiomorpha coarctata* (Polydesmida: Paradoxosomatidae); *Hexadesmus lateridens* (Polydesmida: Fuhrmannodesmidae); *Leptogoniulus sorornus; Oxidus gracilis*, the greenhouse millipede; *Poratia digitata* (Polydesmida: Pyrgodesmidae), *Rhinotus purpureus* (Polyzoniida: Siphonotidae); and *Trigoniulus corallines, the rusty millipede.*

All these millipeds are widespread tramp species that unquestioningly were introduced to Saba by man (Dr. R. Shelley, pers. comm.). When more extensive collections are made, many of these, or other species will likely be documented from the other BES islands and or the other Dutch Caribbean. While millipeds are largely detritivores they are known to prey on emergent plant seedlings in which they can strip the stems of young plants and are also documented as predators of seeds (Koprdova *et al.* 2010) and land snails. As these invasive animals can affect forest regeneration and especially soil arthropod faunas, the actual and potential impacts of introduced millipeds and centipeds may be quite large but remains largely completely unknown. Some millipeds are also known to prey on land snails and could thus be a potential threat to populations of some of the endemic land snails found on the islands of the Dutch Caribbean. In contrast to millipedes (in general), centipedes are predominantly carnivorous and are important predators on arthropods and/or other small animals.

Scolopendra morsitans

Scolopendra morsitans: This centipede is native in Africa, South and Southeast Asia (Pakistan to New Guinea), Southeast China, Taiwan, the Philippines and Australia. It has been reported from Koraal Specht in Curaçao in 1957 (Shelley *et al.* 2005).

Rusty millipede, *Trigoniulus corrallinus*

In Curaçao the Rusty millipede *Trigoniulus corrallinus* (Spirobolida: Trigoniulidae), has been introduced. It is now commonly found in many gardens. It came in some 10 years ago, probably around the year 2000, it seems likely that it was introduced with nursery plants imported from Florida. This millipede originates in Thailand and Myanmar (Burma) and has been introduced in North America, it is found in Florida, USA (Shelley *et al.* 2006).

Greenhouse millipede, *Oxidus gracilis*

Oxidus gracilis, the Greenhouse millipede from Asia is now very common in Curaçao.

4.3 Ants

Exotic ants are a worldwide scourge not only to nature but also to the economy and especially, but not exclusively to the agricultural sector. Ants may attack vegetation, infest bird and sea turtle nests killing

hatchlings and fledglings, but form key household and agricultural pests. Our review showed that no less than 8 species of exotic ants have been documented for one or more of the Dutch Caribbean islands (Wetterer 2008, 2009a,b,c; 2010a,b; 2011, Wetter and Hugel 2008; Wetterer and Porter 2003) (Appendix A). We here only discuss only some of the principal species.

Tropical Fire ant, *Solenopsis geminata*
This is a New World ant that is probably native to the South American islands Aruba, Curaçao and Bonaire. It has probably been introduced to the West-Indies and is known to occur in St. Eustatius where Weber found it in 1936 (Weber 1948) and from St. Martin where Wetterer found it in 2006 (Wetterer 2011). It seems likely that it also occurs on Saba.

Longhorn crazy ant, *Paratrechina longicornis*
This ant has spread practically all over the world. It is a tramp species that easily hitchhikes on cargo and it is often found on ships. It probably originates in South-East Asia and Melanesia. It has been reported from the Dutch Leeward Islands since 1936 (Weber 1948, see Wetterer 2008). More recently it has been collected on Aruba and St. Martin (Wetterer 2008). It is very likely present on Saba and St. Eustatius as well.

The ghost ant, *Tapinoma melanocephalum*
The ghost ant is a tramp species that has spread worldwide. It is now cosmopolitan in the Tropics. Its original range is probably in the Indo-Pacific region. In the Dutch Caribbean it has been reported from Aruba, Curaçao, Bonaire and St. Martin (Wetterer 2009) and it is very likely present on St. Eustatius and Saba as well. Although *T. melanocephalum* does not sting and its bite is not very painful, it can be a serious pest. It can be a vector for pathogens. *Tapinoma melanocephalum* can also be an agricultural pest because it tends populations of phloem-feeding Hemiptera, such as mealybugs, scale insects, and aphids, for their honeydew. Hemiptera cause damage by sapping plants of nutrients and increasing the occurrence of diseases, including viral and fungal infections.

Destroyer ant, *Monomorium destructor*
The destroyer ant, a small yellow ant, is an Old World ant that is probably native to Northern Africa, the Middle East and Central to South-East Asia (Wetterer 2009b). It has been reported from Aruba, Curaçao, Bonaire and St. Martin (Wetterer 2009b). It is very likely present on Saba and St. Eustatius as well. This is a biting ant. It is attracted to electrical fields and chews on isolation of electrical wiring, thus causing damage by short-circuiting electrical equipment and starting fires. In Curaçao Wetterer found it in a manchineel forest (*Hippomane mancinella)* these ants are adapted to arid regions and also enter houses.

Cockroaches

German cockroach, *Blatella germanica*
This species is nowadays cosmopolitan having spread all around the world by human beings. It originates in Asia. In Papiamentu it is called “kakalaka marciano”.

American cockroach, *Periplaneta americana*
The American cockroach originates in Africa, it is the most common cockroach in the Dutch Caribbean.

Introduction of these household pests entails economic damage to dwellings and foodstuffs and the use of expensive pesticides which all amount to important per capita annual expenses, and contamination of the environment.

4.4 Animal diseases vectors and parasites

Varroa* mite, *Varroa destructor

The *Varroa* mite (*Varroa destructor*, formerly it was often referred to as *Varroa jacobsoni,* this name was used as a synonym; however *Varroa jacobsoni* is another species found on the Asian honeybee *Apis cerana*). The *Varroa destructor* mite is an external parasite of honey bees (*Apis mellifera*), it was introduced in Curaçao in 1996, by beekeepers who introduced new colonies of bees, since they felt new genetic material was needed. They were warned and advised against doing so by the Department of Agriculture and Fisheries in Curaçao (Dienst LVV), who were aware of the risks of bringing in *Varroa* mite. Unfortunately there were (and there still are) no legal instruments which could have been used to prohibit such imports. The arrival of *Varroa* had disastrous results. Production of honey went down considerably and the bees became more difficult to handle. At the end of the dry season and at the beginning of the rainy season during periods when there is very little food available (no flowers) the bees are loaded with *Varroa* and can even become very aggressive. In temperate regions the winter months help to keep *Varroa* down, but in the tropics this is not the case. Whereas several part-time beekeepers had had considerable extra income from this enterprise, several of them quit the beekeeping business; while still profitable it became much less attractive. In addition there have been several cases of aggressive bees attacking people and dogs, at least two people were fatally stung. *Varroa* is also present in Aruba. Supposedly there is no *Varroa* in Bonaire. We do not know whether it is present on the Windward Islands.

Yellow fever mosquito (YFM), *Aedes aegypti*

The yellow fever mosquito *Aedes aegypti* was introduced from Africa. It can also transmit dengue fever. It is most active at dusk and dawn, but will also bite during the day, especially in shady areas. This may be the most economically costly and dangerous invasive species introduced to date in the Dutch Caribbean. It is present on all islands of the Dutch Caribbean and is a known vector for the human viral dengue fever, for which outbreaks on the island are a regular occurrence. The species is also a risk to spreading yellow fever, should this pathogen be introduced form South America. Particularly air traffic represents a risk for introduction of infected yellow fever mosquitos, which could then serve as a starting point for an epidemic. The species particularly breeds in freshwater around human dwellings. Aside from the disease risk, the mosquito causes much discomfort to inhabitants of affected areas and is one of the most common unpleasant memories that visiting tourists recall from their visits to the islands. Aside from presenting a health risk and actual health cost to the inhabitants (illness, lost work days), many thousands are spent by government and private individuals to combat this species and prevent outbreaks. The species greatly diminishes living comfort on large parts of the island and affects the quality of the touristic product in a negative way. No cost estimates of economic impact of this species have yet been made, but must run in the millions in value per annum. The islands have many additional mosquito species but aside from the mosquitos of mangrove habitats, the native species have much less tendency to form outbreaks or affect humans. According to Knols (2009), eradication of *Aedes egypti* on Aruba (or other Dutch Caribbean islands) may well be feasible. Breakthroughs that make this possible is the discovery that fungi, such as *Metarhizium anisopliae* and *Beauveria bassiana* not only kill most larvae but also reduce feeding in various mosquito species (e.g. Bukhari *et al.* 2011, Howard *et al.* 2010). The possibility of infecting the species with a wipe out gene is also a new development (Trivedi 2011).

Ant cricket, *Myrmecophilus americanus*

The ant cricket is a species that is a kleptoparasite of ants. The crickets are tiny wingless species that live in and around ant nests and colonies. They disguise their presence using chemical, behavioural and body shape mimicry (Wetterer and Hugel 2008). Most species are not host specific, but this appears to be the case with *M. americanus*. The species has been confirmed from nests of *P. longicornis* in Aruba and St. Martin. As this is a parasite that lives off an invasive species, its ecological impact may be relatively limited.

4.5 Plant diseases vectors and parasites

A large number of plant diseases have been introduced into the Dutch Caribbean. The introduction of plant diseases is best known from Curacao and has been published more extensively on by Heidweiller and van Buurt (2006). For the other islands of the Dutch Caribbean much less is known, but the problem is certainly not less extensive.

A rough chronological listing of important plant diseases and host-specific parasites according to date of introduction in Curacao since the 1960s include: Papaya Bunchy Top (MLO) (early 1960's); Spittlebug (*Aeneolamia varia*) (probably 1986); Whitefly (*Bemisia tabaci*) (1989), Black Citrus aphid, Brown Citrus aphid (*Toxoptera citricida*) (1989); Sweet potato weevil (*Cylas formicarius*) (1990); Palm Thrips (*Thrips palmi*) (1994); Cuban Laurel Thrips (*Gynaikothrips ficorum*) (1996); Citrus miner (*Phyllocnistis citrella*) (1996); Pink Mealy bug, Hibiscus mealy bug (*Macconellicoccus hirsutus*) (1997), Citrus hindu mite (*Schizotetranychus hindustanicus*) (probably around 2000); Papaya Mealy bug (*Paracoccus marginatus*) (2002); Papaya Ringspot Virus (PRSV-P) (2002); Sorghum ergot (*Claviceps africana*) (probably 2003); Red Palm Weevil (*Rhynchophorus ferrogineus*) (2008); White partridge pea bug (*Crypticerya genistae*) (2009).

This is an incomplete listing. There are many more diseases which are probably new, but which have not yet been properly identified. Examples are fungus diseases such as *Fusarium* and *Gliocladium* on palms. Since the 1960, introductions of pest species appear to be on the rise. This is a worldwide phenomenon, most closely linked to the dramatic increase in containerized shipping of goods.

Citrus miner (*Phyllocnistis citrella*) and Citrus hindu mite (*Schizotetranychus hindustanicus*) for example are also present on Aruba and Bonaire. The Red Palm Weevil has not yet reached Bonaire, St. Maarten, Saba and St Eustatius. We have very little information about the plant diseases present in St. Maarten, Saba and St Eustatius.

Black Citrus aphid, Brown Citrus aphid (*Toxoptera citricida*) is present in St Eustatius. This aphid probably originated in South East Asia (Michaud 1998), it was discovered in Curaçao around 1989 and in Florida in 1995. Lethal Yellowing of Palms (LY disease) is caused by a MLO's (Mycoplasma Like Organism). An MLO is a bacterium that lacks a cell wall. Lethal Yellowing is present on St. Maarten.

The diseases mentioned are all agricultural and/or horticultural pests, but many of them attack plants in nature. Such diseases that establish themselves in nature become especially difficult to eradicate. For instance, the Pink Mealy Bug often attacks the Wayaká (*Guaiacum officinale*) and *Acacia tortuosa* (AOD, pers. obs.), Longhorn beetles (*Mionochroma vittatum*, *Eburia* spp. and others) attack manchineel trees (*Hippomane mancinella*) and Bursera trees, especially *Bursera simaruba*. The watakeli (*Bourreria succulenta*) is frequently attacked by the Citrus leaf miner *Phyllocnistis citrella*. Natural vegetation is not

a monoculture and diseases do not seem to spread as rapidly as in agriculture or horticulture. Nevertheless, natural vegetation can serve as a reservoir for the disease or parasite.

More detailed discussion on most species can be found in Heidweiller and van Buurt (2006). We here limit our discussion to six species.

Opuntia cactus moth, *Cactoblastis cactorum*

The cactus moth or nopal moth (*Cactoblastis cactorum*) is a small moth that lays eggs in the leaves of *Opuntia* cactus. It has been documented for Saba (Halteren 1994) and the likely cause for massive declines in the St. Eustatius *Opuntia*'s in the last decades (Freitas *et al.* in prep). The orange larvae eat out the leaf of *Opuntia* cactus, which usually become infected with fungi and the *Opuntia* die. It has already established itself on many other Caribbean islands. In the Western Hemisphere it is found in: the USA. (Louisiana, Alabama, Florida, Georgia, Hawaii, Puerto Rico, US Virgin islands including St. Croix), Mexico (also on Cozumel), Bahamas, Cayman islands, Cuba, Haiti, Jamaica, Dominican Republic, St Kitts and Nevis, Montserrat, Antigua & Barbuda, Trinidad and in its area of origin, Argentina, Southern Brazil, Paraguay and Uruguay. If introduced in the Leeward Dutch Caribbean, it would surely devastate the populations of the local *Opuntia* cacti which play an important role in pioneer vegetations and serve as an important food and water source for the native fauna. With their demise other problems such as increased erosion and invasive plants would probably be worse. The New World screw–worm fly was twice eliminated in Curaçao using sterilized males, which were dropped from airplanes. A similar method is being developed to combat *Cactoblastis cactorum* in Cozumel, Mexico.

This moth is utterly destructive to *Opuntia* plants (Habeck and Bennett 1998; Zimmerman *et al.*. 2004; Zimmerman *et al.* 2005) and was recorded on the neighbouring island of Saba (Halteren 1994). *C. cactorum* was introduced in 1957 in the Caribbean in Nevis to combat *Opuntia* curassavica and other *Opuntia* spp. and was very effective (Habeck and Bennett 1998; Zimmerman *et al.* 2005). It has since been spread both by man and natural means to many Caribbean islands.

Common lime butterfly, Papilio demoleusb

This is a swallow-tail butterfly, newly exotic to the Caribbean and which originated from SE Asia. It is a known and important citrus pest and has established itself in the Dominican Republic (Eastwood *et al.* 2006). The species has established itself around the harbor of St. Eustatius (R. Hensen, pers. comm.). It could easily disperse itself throughout the islands by air.

Red palm weevil, *Rhynchophorus ferrugineus*

Arabian date palms (*Phoenix dactylifera*) were imported from Egypt for landscaping purposes. The Egyptian palms were attractively priced, since many countries had prohibited their import. Despite repeated warnings such palms were imported in Curaçao and some transshipped to Aruba. There was no legislation in place to prohibit such imports and very likely even if such legislation had existed, the importers would have protested and would have campaigned against it successfully. Red Palm Weevil was established in Curaçao by the end of 2008 and reported from Aruba in January 2009. The Red Palm Weevil originates in South East Asia and Melanesia where it is a major pest of coconut palms. It attacks and kills many species of palms and is also a major pest of date palms. It spread to Saudi-Arabia and the United Arab Emirates (1985), Iran (1990) and Egypt (1992). Since 1994 it is also found in Spain (Ferry and Gómez, 2002). More recently it has spread to Israel, Palestine, Jordan (1999), Italy (2004), southern France, the Canary Islands, the Balearic Islands, Greece, Cyprus (2006) and Turkey (2007), Madeira (2008) and has now also been found in California (2010). The Red Palm weevil is also known to attack some agaves and sugar cane. Up to now Bonaire, St Maarten, Saba and St. Eustatius are free of the Red Palm Weevil; the import of palms from Aruba, Curaçao or other areas where the RPW occurs

should be prohibited. Since the weevil hides in the trunk, a phytosanitary certificate as is required by law is an insufficient guarantee as has by now been proven.

To combat the Red Palm Weevil it is necessary to use systemic insecticides, which do not degrade rapidly and give long residual control. The residual effects of the product used should last for about 30 days or more. In the tropics, at higher temperatures, most products will usually degrade somewhat more rapidly and the residual period could be somewhat shorter than indicated (on the label). Contact insecticides are not effective; these will only kill insects on the tree but cannot reach the larvae which are burrowing in the tree. Some insecticides can only be used preventively; they are taken up by the palms too slowly to be effective when the infestation is already present. In such a case the RPW larvae will have killed or weakened the palm before the insecticide can be absorbed. Those insecticides that are absorbed rapidly are those that contain the active ingredient imidacloprid. These are the only ones that can be used if an infection is already present. 'Admire', 'Confidor‘,'Discus', 'Gaucho', 'Imaxx-pro','Marathon' 'Premier', 'Premise', Pronto' and 'Provado' contain imidacloprid. Actara contains thiamethoxam, a similar active ingredient. To avoid resistance building up it is probably best to alternate the use of pesticides containing imidacloprid and those containing thiamethoxam. These insecticides can be applied through the irrigation water, however if the crown of the palm can be reached it can be sprayed on the leaves, absorption will be more rapid and more effective. If the palm is already infected you have to inject an insecticide, preferably one containing imidacloprid (since imidacloprid is absorbed more rapidly than thiomethoxam), directly into the trunk by boring small holes quite deeply into the stem and preferably also spray the crown of the palm. In palms the transport of water in the trunk is more rapid near the centre, thus the boring hole has to be deeper than with dicotyledons. If the palm is not infected do not bore holes since these can later become a conduit for fungus infections. However if the palm is already infected you have no choice but to bore holes and inject the insecticide in its pure form, without diluting it. After use such holes should be sealed with silicon. The use of slow release pellets in the soil around the palm is recommended as a preventive measure. These pellets usually combine the active ingredient with a fertilizer. The fertilizer helps to speed up the uptake of the active ingredient. In Europe it has been noted that some resistance to imidacloprid has already started to develop in RPW. This is a cause for serious concern. Research is going on to develop new insecticides which are effective against this plague. Researchers are working with nematodes of the genus *Steinerema*, a group of small worms, which can be used to combat RPW biologically (Llácer *et al.* 2009). In Curaçao it has been noted that palms that receive too much water are more sensitive to the RPW, the same has been noted in studies in Saudi Arabia (Aldryhym and Al-Bukiri 2003 and Aldryhym and Khalil 2003). The Canary date (*Phoenix canariensis)* is more sensitive than the Arab date (*Phoenix dactylifera),* male palms are more sensitive than female palms. Dwarf dates (*Phoenix roebellinii*) are also attacked. In Curaçao RPW has also attacked *Bismarckia nobilis*, *Washingtonia robusta* and *Pritchardia pacifica* palms, coconut palms and *Pandanus*. Another problem is that these weevils probably serve as a vector for palm diseases such as Gliocladium and/or red ring nematode (see below). Although *Sabal* seems less vulnerable it is not immune from RPW, thus RPW could be a threat to the populations of the indigenous Sabal palm in the Christoffelpark in Curaçao. These palms are not irrigated and are probably less vulnerable to RPW attack but still some risk probably exists, either from the RPW itself or from diseases such as *Gliocladium* or Red ring nematode for which RPW could be acting as a vector. Although RPW is also reported to attack agaves, especially the large agaves, they have not yet been found to attack local agaves.

Another way of controlling RPW is by setting out traps for the adults. These traps consist of plastic bins. In Curaçao they are filled with water and some PPG radiator fluid in the bottom of the bin to kill the insects once they are in the trap. Pheromones and molasses are used as attractants. Some operators of traps cover the smooth plastic vertical side(s) of the bin with jute cloth; it can be applied with glue quite easily. This provides a suitable landing platform for the beetles which can then walk to the entrances.

Coconut scale, *Aspidiotus destructor*

In old colonial reports, plagues and pests and the damage they did are frequently mentioned, but usually the descriptions of these events are not detailed enough to allow for a definite identification of the organisms involved. Renkema (1981) mentions many plagues that affected harvests of Sorghum and other crops in the 19th century. A report from 1831 specifically mentions damage by "pies–pies" (mealy bugs and scales). Around 1841-1843 many coconut trees died after being attacked by "schildluis"; these reports may refer to the Coconut scale "*Aspidiotus destructor*", which was probably introduced around this time during the 19th century. The same species was only introduced into Hawaii in the 1960s but today it continues to spread throughout the Pacific. It is known to affect many crop species, among which bananas and breadfruit. Nowadays it seems strange that this scale or any scale could kill off so many coconut trees. It is reported that almost all coconut trees died, except for those on two plantations in the Eastern (upwind) part of the island. The effective virulence of the disease on the current coconut trees seems to have become much less. This in part may be due to increased resistance or replacement of vulnerable coconut trees with new strains more resistant to disease. We also have to remember that in those days there was no irrigation available by windmills, which were introduced only in the late 19th century and that this plague struck during a period of severe drought, which may have made the trees more vulnerable.

Longhorn beetle, *Mionchroma vittatum*

The longhorn beetle *Mionochroma vittatum* is native to nearby Venezuela; nowadays in Curaçao it attacks various trees including the introduced West-Indian Mahogany tree (*Swietenia mahogany*). The local mahogany wood is almost always riddled with the large tunnels of these boring pests. In the past Mahogany trees were locally used to make furniture, the darker and harder West-Indian mahogany wood was preferred and was imported, mostly from Santo Domingo (nowadays named the Dominican Republic), but some local wood was also used. In the old local furniture we see no traces of boring tunnels, nor do we have any older reports mentioning boring insects in mahogany, which leads to conclude that the *Mionochroma vittatum* longhorn beetles must have been introduced. The much smaller *Eburia* longhorn beetles are probably native.

Tabebuia plague, (*Thrips* sp.?, Cossidae?)

A new plague species attacking the indigenous pale pink trumpet tree *Tabebuia pallida* (syn: *Tabebuia heterophylla*) is present on Saba and St. Eustatius. The White cedar thrips, *Holopothrips iniquilinus* (Family: Phlaeothripidae) has been identified as a problem on Dominica and a similar diseases has been seen on Saba in 2006.

During 1993 and 1994 Dr. Paul van Halteren of the Plant Protection Service in Wageningen investigated the extensive mortality among White cedars, especially in the lowerlying erosion-prone shore-zone woodlands (Halteren 1994). The species responsible for the damage, was identified as the caterpillar of an undescribed species of moth (Genus *Psychonoctua* Fam: Cossidae). No literature on its occurrence or possible pest control was available. According to the Saba Conservation Foundation, replanting with resistant tree species seemed to be the best cure. In the years since, some White cedar have survived. These may form the basis for recovery of the coastal *Tabebuia* woodlands. However, natural vegetation recovery is being hindered by goat grazing. This offers favorable conditions for the propagation by unpalatable invasive plant species.

4.6 Fungi

Ganoderma butt rot, *Ganoderma zonatum*

Ganoderma butt rot of palms (*Ganoderma zonatum*), see: Elliot and Broschat (2000). In September 2003 two infected palms were found in Curaçao, these were destroyed. (Heidweiller and van Buurt 2006). In 2010 an additional case was found. In 2011 an infected *Sabal palmetto* palm was found in front of the Curaçao airport building. *Ganoderma zonatum* is found in Florida and Georgia. When importing palms for landscaping from the US, there is a risk of this fungus coming in. It is lethal and cannot be treated with fungicides. Infected palms have to be destroyed and where an infected palm stood, no new palm can be planted. It seems likely that it is now established at several locations in Curaçao.

Watapana tree (*Caesalpinia coriaria*) die-offs

In the past there have been large die-offs of divi-divi or watapana trees (*Caesalpinia coriara*), on all three Leeward Islands, Aruba, Curaçao and Bonaire, which were especially severe in Bonaire. In 1987 there was a large die-off in Bonaire; in some areas 100 % of all watapana trees had died by August 1990. It was estimated that about 60% of all the watapana trees on the island died. In 1992 there were similar die-offs in the Peninsula de Paraguaná and also in the area around Coro, Venezuela. At the Universidad Central de Venezuela (UCV) in Maracay, Venezuela fresh samples of living wood from diseased trees in Curaçao were analyzed and it was concluded that the die-offs were caused by an unidentified fungus belonging to the fungi imperfecti (Deuteromycota or “Deuteromycetes”); the green leafhopper (*Empoasca krameri*) being an important vector. The samples were taken in the morning, were taken to Venezuela the same day, in a cool box and arrived at the laboratory in Maracay in the afternoon, where they were set in cultivation on agar immediately (pers. comm. K.A. Heidweiller, who took and carried the samples). Researchers from the Universidad de Coro (Universidad Nacional Experimental Francisco de Miranda (UNEFM), who analyzed trees from Bonaire think high soil salinity; which is typical of Bonaire (AOD, pers. Obs.) , may have been a contributing factor. The islands receive salt particles from the sea which are suspended in the air, during extended dry periods the salt content in the soil builds up (GvB). The island receives less rainfall and in many areas salt loads in the soil are likely higher than in Curaçao Tests showed a strong correlation of high sodium content in both leaf and roots of severe damaged and moderately damaged trees. The sodium content as well as potassium content was much higher in the soils of highly affected areas (Diaz 1992).

Researchers from De Dorschkamp Instituut voor Bosbouw en Groenbeheer Wageningen, The Netherlands concluded that the disease was most likely not caused by a fungus, but by a virus, rickettsia or MLO, they recommended testing samples in a regional laboratory (the problem being that the transportation time to a laboratory in the Netherlands would take much too long). The spread of the disease from one point on the island and the high mortality seem to indicate that the pathogen was introduced on the island. It seems there was a similar watapana die-off in Bonaire in the 1920’s, also after a period of extended drought (presumably after the 1919-1920 extended dry period, GvB) and similar die-offs have been described from Curaçao (Kam and Vink 1991).

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5. Preliminary list of Alert species (agricultural and animal pests, diseases, vectors) by G. v Buurt

5.1 Molluscs

Giant African Land Snails, *Achatina spp.*
Three species of Giant African Land snails are known invasive species and are present in the Caribbean; the Giant African Land snail (*Achatina achatina*), the Giant (East) African Land snail *Achatina fulica* or *Lissachatina fulica* (this species is the most damaging) and the Giant West African Land snail *Archagatina marginata*. *A. fulica* is already present on St. Maarten (discussed in list above) but these other species could also easily reach one or more of the Dutch Caribbean islands.

Giant African Land snail, Limicoraria aurora
The African snail, *Limicolaria aurora* is present on Martinique; it was introduced around 1986 from West-Africa as a food item. Some fear that this is a pest that could be even worse than *Achatina fulica.*

5.2 Insects

Beetles & Weevils (Coleoptera)

Redbay ambrosia beetle, *Xyleborus glabratus*
In the tropics this beetle is known to attack avocado trees (*Persea americana*). It infects them with the associated laurel wilt fungus *Raffaelea lauricola*. This fungus gradually spreads through much of the outer sapwood. Attacked trees eventually exhibit wilted foliage with a reddish or purplish discoloration. The foliage eventually turns brown and tends to remain on the branches. The host weakens and dies. The Redbay ambrosia beetle is native to India, Japan, Myanmar, and Taiwan. However, the origin of the laurel wilt fungus that accompanies the beetle is not known. The fungus is presumed to have been introduced with the beetle. Both were first found in Georgia, where it attacks the native redbay tree (*Persea borbonia*) which belongs to the same genus as the avocado tree. Beetle and fungus now occur in Florida, where it attacks the avocado tree. The redbay ambrosia beetle appears to be most attracted to woody plants in the Lauraceae (laurel) family, although there are reports in Asia of the beetle attacking some plant species in Fabaceae, Fagacea, and Dipterocarpaceae (Crane and Peña 2008). This means that if it were introduced in the Dutch Caribbean it might be able to attack not only avocados but possibly other trees in such families as well. *Erythrina velutina* (Bonchi kabai) is an example of a tree in the Fabaceae.

(Florida) Palmetto weevil, *Rhynchophorus cruentatus*
Nowadays wild harvested palmetto palms (*Sabal palmetto*) are imported from Florida for landscaping purposes. The (Florida) Palmetto Weevil (*Rhynchophorus cruentatus*) could come in with such imported palmetto palms. Although this Palm Weevil is not as damaging as the Red Palm Weevil, which is considered the most destructive palm weevil, this is of course another pest we can do without.

Agave weevil, *Scyphophorus acupunctatus*
The agave boring weevil (*Scyphophorus acupunctatus*) is a weevil which tunnels into the base and roots of agaves; these then become infected and die. Agaves are keystone species; bats, hummingbirds and many other birds depend on it for food. In Curaçao and Bonaire we find the indigenous *Agave vivipara*

and *Agave boldinghiana*. In Curaçao we find the endemic *Agave petiolata* (possibly extinct). Two species of Agave are endemic to Aruba. These are *Agave rutteniae* which is found only on the south slope of the Hooiberg and *Agave arubensis* which is found in Rooi Fontijn and its immediate neighborhood (Wagenaar Hummelinck 1938). Of course such a pest would also affect many introduced agaves in the wild and those used in landscaping. The agave weevil is found in the USA, Puerto Rico, US Virgin Islands (including St. Croix), BVI, Mexico, Costa Rica, El Salvador, Nicaragua, Guatemala, Honduras, Cayman Islands, Cuba, Haiti, Jamaica and the Dominican Republic. In the British Virgin Islands this weevil did a lot of damage (Perry 2000). Great care should be taken when importing agaves or yuccas and Beaucarnias (pony tails) for landscaping.

Mango seed weevil, *Sternochaetus mangiferae*

The Mango seed weevil is probably native to the Indo-Burma region, it is now found in southern and eastern Africa, most Asian countries, parts of the South Pacific and in Hawaii. It is also present on many Caribbean islands; Barbados, Dominica, Guadeloupe, Martinique, St. Lucia, Trinidad and Tobago, British Virgin Islands, Grenada, Montserrat, St. Vincent and the Grenadines and in parts of South America (French Guiana). The mango seed weevil attacks the seed, and not the flesh of the fruit, thus the mango seed weevil is not a true pest of production, but its activities may downgrade the fruit, and severely reduce seed germination. The mango is the most important fruit tree in the Dutch Caribbean.

Mealybugs (Hemiptera)

South American *Harrisia* cactus mealybug, *Hypogoecoccus pungens*

This is a mealybug that attacks candelabra (columnar) cactus; it covers them completely and kills them. This South-American mealybug is already present in Barbados and in Puerto Rico (Zimmerman *et al.* 2010) and also in Florida.

Bees Termites and Ants

Africanized Honey Bee (AHB), *Apis mellifera scutellata*

Africanized honey bees could come in, most likely with a nest on a ship. There has been a case of a nest with aggressive bees on a ship at the Curaçao Drydock Company; they were fumigated. It is not known whether these bees were Africanized. Often it is said that there are Africanized honey bees on the islands. Anytime aggressive bees are encountered there is speculation or it is simply assumed that these bees must be Africanized. However bees infected with *Varroa* mites can also become very aggressive especially at the end of the dry season (see earlier). The very aggressive bees in Aruba in 1938 (Bitter, 1950) hark back to a time when there were no Africanized bees in the Americas. To determine whether bees are Africanized it is necessary to do DNA analyses. A DNA analysis of a sample of bees can also give an indication to what extent the bees have been Africanized. The AHB also have slightly shorter wings, which can be reliably recognized only by performing a statistical analysis on micro-measurements of a substantial sample. Up to now up such tests have not been done and there is thus no definite proof that Africanized bees are present in the Dutch Caribbean. Africanized bees have however established themselves on Jamaica, Puerto Rico and St. Croix (Rivera-Marchand *et al.* 2008), so it is not unlikely that they could be present on some of the Dutch islands. According to Freitas *et al.* (2009) the Africanized honey bee is suggested to occur on St. Maarten, Saba and St. Eustatius. We however have not found clear evidence to support this and consider the species as a key Alert species to be on the watch out for.

Formosan subterranean termite, *Coptotermes formosanus*

The Formosan subterranean termite originates in Southern China. It has been transported worldwide from its native range to Taiwan (Ilha Formosa), Japan, Sri Lanka, Hawaii, South Africa and the

continental US where it is found in California, Texas, Louisiana, Alabama, Florida, Georgia, South Carolina, North Carolina, Tennessee and Mississippi.

This is a very destructive termite that can also live in the full tropics (it is present in Sri Lanka). It builds its colonies either underground or above ground. This termite is very hard to combat. Unlike the native arboreal termite, *Nasutitermes costalis,* which only attacks dead wood*,* it will also attack live wood and plants and is known to attack sugarcane. Once established it has not been possible to eradicate it from an area.

Yellow jacket wasp, *Vespula squamosa*
A nest of these was once found in Curaçao, they were exterminated. Reports of this species for St. Eustatius (Esteban 2009) could not be confirmed.

Red fire ant, *Solenops invicta*
The red fire ant is one of the many ants that is spreading worldwide. It is firmly established in the Caribbean (Morrison *et al.* 2004). It is known to have many negative effects on native flora and fauna. It may be present in the Windward Dutch islands, but this has not yet been confirmed.

Flies, Mosquitos (Diptera)

Carambola fruit fly, *Bactroceras carambolae*
The Carambola fruit fly, member of the Oriental fruit fly (*B. dorsalis*) complex is found in northern South America and is a very destructive fruit fly (Sauers-Muller 2005). Other species of the complex (like *B. dorsalis* and *B. invadens*) are also known as being invasive in other parts of the world and are of quarantine importance.

New World screw–worm fly, *Cochliomyia hominivorax*
The New World screw–worm fly (*Cochliomyia hominivorax*), is an obligatory parasite of living warm-blooded animals, including man. The female oviposits on any lacerated or bloody area or wound. The New World screw–worm fly had established itself on Curacao twice; it was extirpated both times, which required costly campaigns. It is supposed to have been introduced in Curaçao at least since the 1860's (Baumhoven 2002). The first campaign to eradicate it took place in 1954, when this fly was successfully extirpated using sterilized males. These males were sterilized by irradiation with Cobalt 60, and then released in the wild from airplanes, the so-called SIT method (Sterile Insect Technique). About 150,000 sterile screwworm flies per week were released over Curacao, a small island of 444 square kilometers (176 square miles); within 3 months and 4 generations of the targeted insect, the screwworm was eradicated from the island. From the Curacao experiment, it was learned how to put together a full-scale eradication program. Components of the experiment included mass rearing of screwworm flies, proper sterilization equipment and procedures, and an efficient aircraft method of dissemination (Knipling 1959). In the 1970's the screw-worm fly was reintroduced and by the end of 1975 it was firmly reestablished. It was found on dogs and goats which were the principal hosts, but also on other mammals. During the Dec 1975 – August 1976 period, there were 14 cases, including one possible death, of screwworm infestation in humans. In those years thousands of head of live cattle were yearly imported to Curaçao from infested areas in South America **(**Snow *et al.* 1978). This time the screwworm fly was extirpated using a combination of attractants, poisoned bait and the SIT method (Baumhoven 2002). By October 1977 the screw-worm fly was again extirpated. Nowadays live cattle are not being imported anymore, but eggs of the screw-worm fly can come in with hay. Regulations exist for the importation of hay. Hay can only be imported, from areas which are free of screw-worm fly and need a phytosanitary certificate, which states from which region the hay came from. There have been several

cases where people tried to import hay with forged phytosanitary certificates from Venezuela. In such cases the hay is denied entry, but it can be shipped back. Thus there are no serious consequences for the importer. Even though forgery is a crime it is not possible to prove who forged the document and whether the importer knew the document was forged, thus such cases are not prosecuted. In cases where it is suspected that the document is forged, the issuing authority in Venezuela is contacted to check whether the document is authentic. Up to now these authorities have been cooperative. The risk that the screw-worm fly will be reintroduced, requiring yet another costly campaign to extirpate it is ever-present. In Aruba the New World screw–worm fly was present more recently. Although Aruba was previously free of the screw-worm fly there were a few isolated cases in 1987 and some were found in meat in 1998 (Pieter Barendsen, Vet Serv. Aruba in interview with Diario 10 March, 2005). There was a more serious outbreak in March 2004. It is suspected that the infection entered Aruba sometime in January 2004 with the illegal importation of an infected animal. By October 2004, the screw-worm fly was extirpated after a rapid response campaign with the assistance of the Mexican-American Commission for the eradication of the screwworm and the USDA-ARS (United States Department of Agriculture - Agricultural Research Service). Because of the strong trade wind and the small size of the island, which would tend to blow sterile flies released from aircraft off the island, the sterile insects were not released from aircraft. Sterilized pupae were imported in foam boxes and were allowed to hatch and fly out at several release sites. Bonaire, St. Martin, Saba and St. Eustatius have traditionally been free of the screw-worm fly (Vargas-Téran *et al.* 2005). On the 11th of March 2011, screwworm flies were again reported from Aruba (pers. comm. Pieter Barendsen).

The Asian tiger mosquito, *Aedes albopictus*

The Asian tiger mosquito originates in Asia. It was also found on many Pacific islands and was introduced to some of the Hawaiian Islands in the late 1800's. In 1985 it was found in the continental US. In recent years the range of this mosquito has greatly expanded, it is now found in North America (US 1985, Mexico 1993, El Salvador, Guatemala 1995) and South America (Brazil, 1986, Bolivia 1995, Colombia 1996), the West Indies (Dominican Republic 1993, Cuba 1995, the Cayman Islands 1997), Africa and Europe. In some areas the Asian tiger mosquito (ATM) rapidly displaced populations of the yellow fever mosquito (YFM) *Aedes aegypti*, but in some other habitats the yellow fever mosquito continued to thrive. The ATM is a major vector of dengue (all four serotypes) and is known to have caused epidemic outbreaks of this disease. It is also a vector of yellow fever. It tends to occupy a greater range of habitats than the YFM which tends to make it a more common mosquito. It is active at night and tends to be active during the daytime as well, to a larger extent than the *Aedes aegypti*. ATM can transmit many viruses, among them Dengue, West Nile Virus, Yellow fever, Chikungunya fever, Western equine encephalitis, Eastern equine encephalitis, Venezuelan equine encephalitis, LaCrosse encephalitis. It also transmits dog heartworm. The eventual introduction of this species will be almost impossible to stop (Reiter 2010); measures should concentrate on how best to deal with its presence once it has arrived.

Dragonflies (Anisoptera)

The Crimson darter, *Crocothemis servilia*

The Crimson darter is a dragonfly which is native to East and South-East Asia. It has been introduced in Hawaii and has now reached Florida (1971), Cuba, Jamaica and Puerto Rico (pers. comm. Dennis Paulson). Since it has been spreading relatively rapidly it is not unlikely to reach the Lesser Antilles. In the Indonesian islands it is common and widespread, which indicates that it probably spreads to islands quite easily. It is not known how the arrival of this species would impact on the local fauna. However, dragonflies are important freshwater and aerial predators which can have an important impact on certain pollinators.

Butterflies (Lepidoptera)

South American tomato pinworm, *Tuta absoluta*

Tuta absoluta is a devastating pest of tomato, it also attacks egg plants and common beans. It originates in South America but is now rapidly spreading in Europe and Northern Africa. It is present in all of south America, including Venezuela and Colombia. This pest is difficult to control; it develops chemical resistance very rapidly. There is as yet no effective biological control. Trapping with baits and pheromone lures is used to combat this pest. See www.tutaabsoluta.com

5.3 Mites and Ticks

Red palm mite, *Raoiella indica*

A very recent introduction in the Caribbean is the Red Palm mite (*Raoiella indica*). The first Western Hemisphere report of the red palm mite was in 2004 from the eastern Caribbean island of Martinique. The mite was confirmed on the islands of Saint Lucia and Dominica in 2005 (Kane and Ochoa 2006). In 2006 the mite was reported as established in the Dominican Republic, Guadeloupe, Puerto Rico, Saint Martin and Trinidad-Tobago. In 2007 the US Virgin Islands, Granada, Haiti, Jamaica and Florida have been added to the list of islands and countries infested with the red palm mite. Gutiérrez *et al.* (2007) recently reported the red palm mite from the state of Sucre in Venezuela, SA. In all instances, this mite has established itself on various palms (Arecaceae), with significant outbreaks on coconut palms, *Cocos nucifera* L. In addition, significant infestations have been observed on banana and plantain species (*Musa* spp., Musaceae) on most islands with additional infestations observed on heliconias (Heliconiaceae), gingers (Zingiberaceae), bird of paradise (Strelitziaceae) and screw pine (Pandanaceae). This mite can be controlled with acaricides such as for example L-Vydate, but since they spread out almost everywhere, reinfection will take place continually and chemical control will not be very effective. The species probably cannot be prevented from arriving in the islands where it is not yet present, because of its mode of dispersal by the wind.

Tropical bont tick, *Amblyomma variegatum*

The tropical bont tick is a major vector of *Rickettsia africae*, the agent of African tick bite fever (ATBF), a mild but common tickborne disease. The tick was originally introduced in Guadeloupe in the early 19th century from Senegal, but has now been spreading and has become endemic on many other islands in the West-Indies. In 1948 it was present only on Guadeloupe, Marie Galante and Antigua (Barré *et al.* 1995). It can be introduced with the transportation of cattle and also by the cattle egret (*Bubulcus ibis*). This tick is nowadays present on Guadeloupe, Marie Galante, La Désirade, Martinique, Dominica, St. Lucia, St. Vincent, St. Kitts and Nevis, Montserrat, Antigua, Anguilla, US Virgin Islands, St.Croix, Barbados. An eradication program for *Amblyomma variegatum*, is in progress in the Caribbean; St. Kitts, St. Lucia, Montserrat, Anguilla, Barbados and Dominica qualified for 'provisionally free' certification by 2002, although St. Kitts was re-infested in 2004.

Amblyomma variegatum is also a vector for *Ehrlichia ruminantium* (formerly *Cowdria ruminantium*), another bacterium in the *Rickettsiales* group, that causes heartwater or cowdriosis in cattle. It is likely that several different strains of *Ehrlichia ruminantium* were introduced from African countries (Vachiery *et al*, 2008). *Amblyomma variegatum* is not present on Aruba, Curaçao and Bonaire.

Lyme disease ticks, mostly of the genus *Ixodes*

Lyme disease is a serious bacterial disease that is transmitted by ticks, it also attacks human beings. It causes skin rash, arthritis in the joints, affects the heart and nervous system; if misdiagnosed and

treated late it can lead to loss of memory and can even be fatal. It is mostly transmitted by ticks of the genus *Ixodes*, sometimes by other ticks as well. The most common Lyme Disease tick vectors in the US and Canada include *Ixodes scapularis* (Deer Tick), *Ixodes pacificus* (Western Black Legged Tick), *Amblyomma americanum* (Lone Star Tick). *Ixodes angustus* has been shown to be a competent vector in experiments. *Ixodes spinipalpis* is implicated as a vector as well. *Ixodes muris* has shown to be a weak vector of Lyme disease and more research is needed. All of these ticks can be infected with Lyme spirochetes. The spirochaete bacterium *Borrelia burgdorferi* is the main cause of Lyme disease in the United States whereas in addition to *Borrelia burgdorferi* the spirochaetes *Borrelia afzelii* and *Borrellia garinii* cause many European cases. The disease is named after the town of Lyme, Connecticut, USA, where a number of cases were identified in 1975. There have also been many cases of tick-transmitted Lyme disease in Brazil.

In Curaçao up to now (Jan. 2011) one case of Lyme disease has been detected in a dog that came in from the Netherlands (pers. comm. O.B. de Haseth, Head Veterinary Service, Curaçao). In the Netherlands Lyme disease is spread by the tick *Ixodes ricinus*, which carries the spirochaete *Borellia burgdorferi*. The most common tick in Curaçao is the Brown dog tick *Ripicephalus sanguineus.* The Brown dog tick has been shown to be able to carry Lyme but their ability to pass it on is under study. On dogs in Aruba, Curaçao and Bonaire this is the only dog tick present. Although the brown dog tick is not its principal vector, these ticks can also transmit Rocky Mountain Spotted Fever (RMSF), which is caused by a bacterium in the *Rickettsiales* group the bacteria *Rickettsia rickettsii*. This disease can be lethal. The name “Rocky Mountain spotted fever” is somewhat of a misnomer. This disease occurs in many areas of the United States other than the Rocky Mountain region. It is now recognized that this disease is broadly distributed throughout the continental United States, and occurs as far north as Canada and also in parts of Central America and parts of South America.

Babesia is a genus of protozoa found as parasites in red blood cells and transmitted by ticks. There are numerous species which cause babesiosis in both wild and domestic animals and a malaria-like illness, which can be fatal, in humans. *Babesia vogeli* is present in Curaçao. The bacterium *Ehrlichia canis* which causes “karpattenziekte” in dogs and which is also transmitted by ticks is also present in Curaçao.

In order to prevent new species of ticks and the diseases they may carry (such as among others, Lyme disease, ATBF and RMFS), from entering these islands, it is necessary to use pet passports. In such a passport a controlling veterinarian signs and stamps a page after the pet is free of ticks and has been treated for ticks 48 hours before travelling. It is also necessary to thoroughly check all imported cattle. In general it is necessary to follow the recommendations of the OIE (Office International Epizooties) which can be found at http://www.oie.int/

5.4 Nematodes

Red ring nematode, *Bursaphelenchus cocophilus*

This nematode kills palms (red ring disease of palms), it is found on many Caribbean Islands, in South America (among others Venezuela and Trinidad & Tobago) and in Florida. It is spread by palm weevils. Nowadays wild harvested palmetto palms (*Sabal palmetto*) are imported from Florida for landscaping purposes. An important vector, the Red Palm Weevil (*Rhynchophorus ferrugineus*) is already present on Curaçao. The (Florida) Palmetto Weevil (*Rhynchophorus cruentatus*) could also come in with imported palmetto palms and is also an Alert Species. The introduction of Red ring nematode is another disaster waiting to happen.

6. Discussion

Due to their small size and isolation, islands present many limitations to ecology and economy. However, one of the traditional “strengths” of islands has been the paucity of diseases and pests for the same reason (long-term isolation from mainland areas). This presents advantages to man in terms of health, and prospects for agriculture. This relative “advantage” can only be maintained when invasive pests and diseases are actually kept out. Today more and more this advantage is being lost due to the failure to prevent alien pests, pathogens and vectors from invading island ecosystems. Due to human and commercial traffic, world-wide the rate of introductions is only increasing. Because of their traditional isolation, island systems are also often extra sensitive to IAS, which today represent one of the major threats to unique island biodiversity. This is also the case in the Dutch Caribbean.

6.1 Key Pathways of Introduction

With globalization and much faster transport by airplane and container ships and shipments from all over the world, the problem of invasive species and the fast spread of animal and plant diseases is now a recognized major world problem. The Caribbean area is not exempt from these problems. Invasive species are present on many other islands in the Caribbean many of which have very detrimental effects in terms of economy, ecology, and human health.

Nowadays transport is much faster than in the past and many organisms that hitchhike on cargo have a much greater chance to survive the journey; the fact that cargo is nowadays containerized is also an important factor. The standardized freight container was one of the most important innovations of the 20th Century. Containerized cargoes travel from their point of origin to their destination by ship, road and rail as part of a single journey, without unpacking. This simple concept is the key element in cheap, rapid transport by land and sea, and has led to a phenomenal growth in global trade. Likewise, containerized air cargo has led to a remarkable increase in the inter-continental transportation of goods, particularly perishable items such as flowers, fresh vegetables and live animals. In both cases, containerization offers great advantages in speed and security, but reduces the opportunity to inspect cargoes in transit. An inevitable consequence is the globalization of undesirable species of animals, plants and pathogens. Moreover, cheap passenger flights offer worldwide travel for viral and parasitic pathogens in infected humans. The continued emergence of exotic pests, vectors and pathogens throughout the world is an unavoidable consequence of these advances in transportation technology (Reiter 2010).

There is also a large international trade in nursery plants, including trees and sometimes large palms for landscaping. Nowadays on many Caribbean islands trees and large palms are imported for the landscaping of hotels or other tourist projects. Such large palms and trees are transported in open-top containers. Then there is a large pet trade which also deals in exotic animals, which did not exist to this extent in the past. Dogs and other house pets now travel all over the world with their owners, usually there are adequate veterinary rules, but in some cases epizootics like ticks and the diseases they may carry, can still come in. St. Eustatius and St. Maarten in cooperation with the USDA have sent and are sending control officers for workshops in training and capacity building around the Caribbean to address the issue of IAS especially with regards to agricultural pests. However, all information that is retained by the inspectors is of value to the management of other species as well (R. Hensen, pers. comm.).

6.2 Alert species list

The current Alert list is based on experiences in other Caribbean countries and existing trade patterns and takes into account whether species could survive in an arid climate. The listing has a subjective element. Since the list is meant to be used to educate the general public, customs, people working in pest control etc.; it cannot be all encompassing. In order to be workable it has to be somewhat limited, it is however necessary to update and adapt such a listing regularly. The list focuses on agricultural pests, diseases and vectors, but many "regular" plant and animal pests (of which probably many have been introduced by man) have not been included.

The list will enable the respective "biosecurity units" (see below) to develop contingency plans against the "Alert" species most likely to enter. For example one could keep a supply of the appropriate chemicals needed on the island in advance. When the Red Palm Weevil arrived in Curaçao the insecticides which are most effective against this plague were in short supply and many could not be legally imported since the product had to be registered, a quite lengthy process. Last but not least there is always the unknown, a new species, which is not listed as, or perceived to be an alert species may cause problems unexpectedly. Thus the listing of "alert" species should be seen as a valuable tool and not as a "cure all".

Some alert species can be kept out quite easily. The introduction of the Red Palm Weevil in Curaçao and Aruba was completely unnecessary. It was known that palms from Egypt were infected and that most European countries had prohibited import of date palms from the Middle East; ample warning was given. A simple import prohibition would have sufficed to keep the RPW out. A problem is that those who stand to profit from unrestricted importation are usually not the same people as those who suffer when plagues come in. Since palms could be bought for about U$ 300, - in Egypt and sold locally for about U$ 5500, - or more *in situ*, there was a large profit potential left even after subtracting transportation costs, import duties and handling.

While some importers lost palms, a new market for certain insecticides was created and also a new market for trees in landscaping other than palms, such as for example black olive trees, to replace the lost palms. This is a general problem. When the Dominican Republic enacted a prohibition against the importation of all palms, the US protested that this was against WTO rules and would prejudice US exporters. Importers in the US resisted a prohibition on the importation of live palms. Unfortunately it was not until Jan 25, 2010 that a Federal Import Quarantaine Order was issued to forbid the importation of palms in the US. In August 2010 the Red Palm Weevil was discovered in Laguna Beach, California in what was already an advanced stage of infestation, so that it is feared that The RPW has already dispersed itself (Ferry 2010).

Other Alert species are almost impossible to stop. The Red palm mite (*Raoiella indica*) will very likely arrive carried by winds, and the Asian Tiger Mosquito (*Aedes albopictus*) will also arrive eventually. In these cases one should be prepared to handle their presence.

Most Alert species fall somewhere between these extremes and many can be kept out with sensible measures.

6.3 Awareness

More awareness of the problems new plant diseases and invasive species can cause is needed. The Red Palm Weevil, which was first discovered in Curaçao in December 2008 and which was found in Aruba in January 2009 did and is doing a lot of damage to various species of palm trees. This has created some awareness of the problems invasive species can cause.

Regularly updating and reevaluate a list of “Alert species”, is a key task of the biosecurity unit. This unit should also establish contingency plans to combat the plant diseases and invasive alien species on this listing. In this section we present a preliminary listing of Alert species for the islands of the Dutch Caribbean. The responsible biosecurity unit will need to maintain close contacts with regional organizations such as FAO, CABI and USDA/Aphis and with local commercial pest control companies as well as with local and regional companies supplying chemicals to combat species (insecticides, acaricides, fungicides, herbicides, mollucides etc.).

7 Conclusions and Recommendations

- It is most important to prevent new pests, plagues and invasive species coming in; this should always be the first priority. Once they come in and have established themselves most of them are almost impossible to eliminate and cannot be eradicated.
- To keep unwanted species out adequate legislation is needed.
- Some pests, plagues and invasive species can still be eliminated in an early stage by acting rapidly; this is the main role of a biosecurity unit. This biosecurity unit should maintain good relations with various stakeholders and the general public, as these can act as critical informants.
- A general awareness of these problems is needed to generate the required feed-back and support
- A “biosecurity unit” is also an essential tool with which to control the numbers of those pests, plagues and invasive species that cannot be eradicated.
- Use of pesticides has only limited effect; often the organisms develop resistance fairly rapidly. Chemical control is also very costly and in the long run it is not effective. Use of sterilized males and/or trapping with bait and/or pheromones and/ or food attractants can sometimes be effective. In general an Integrated Pest Management (IPM) strategy has to be developed and used. In some cases biological control has been used successfully and can help to contain the plague and limit the damage

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Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Justification

Report number: 193/11
Project Number: 4308202004

The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of IMARES.

Approved: K. Booi

Signature:

Date: 27 December 2011

Approved: F.C. Groenendijk, MSc.
Head of Department

Signature:

Date: 27 December 2011

List of current exotic agricultural pests and terrestrial animal and plant diseases and disease vectors documented in Dutch Caribbean islands

Definition: Invasive species are non-indigenous species (or exotic species) introduced by historic human actions, whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health (US government definition)

Redn shading = current invasive species

Species	common name	region of origin	approx. date of introduction	Aruba	Bonaire	Curacao	Saba	St Eustatius	St Maarten	Impacts ecol/econ	Principal determnant for presence	Principal habitat/ group affected	Prospects for control	Priority for research	Priority for control measures
Mollusca															
Achatina fulica	Giant East African Land snail									*high*		*vegetation*	*low*		
Zachrysia provisoria	Cuban garden snail		2000 <							*high*		*vegetation*	*low*		high
Diplopods															
Scolopendra morsitans		Africa, Asia	> 1957							?		*soil arthropods*	?	low	low
Asiomorpha coarctata										?		*soil*	?	low	low
Hexadesmus lateridens										?		*soil*	?	low	low
Leptogoniulus soromus										?		*soil*	?	low	low
Oxidus gracilis	Greenhouse millipede	Asia													
Poratia digitata										?		*soil*	?	low	low
Rhinotus purpureus										?		*soil*	?	low	low
Trigoniulus corallinus	Rusty millipede	Burma, Thailand	2000							?		*soil*	?	low	low
Ants				Aruba	Bonaire	Curacao	Saba	St Eustatius	St Maarten						
Solenopsis geminata	Tropical fire ant	Trop. S. America, West Indies	<1936							*high*					
Paratrechina longicornis	Longhorn crazy ant	India													
Monomorium floricola	Flower ant	Trop. Asia	<1937							high					
Tapinoma melanocephalum	Ghost ant	old world tropics	<1994							high					
Tetramorium lanuginosum	Wooly ant	Trop. Asia	<2004							limited					
Tetramorium bicarinatun	Penny ant,	SE Asia	<2007							high					
Monomorium destructor	Destroyer ant	old world	<1999							high					
Wassmania auropunctata	Little fire ant	Neotropics	<1972							high					
Cockroaches															
Blatella germanica	German cockroach										human habitation	human habitation	low	low	low
Periplaneta americana	Palmetto bug										human habitation	human habitation	low	low	low
Animal diseases vectors parasites				Aruba	Bonaire	Curacao	Saba	St Eustatius	St Maarten						
Varroa destructor	Varroa mite		1996							high					
Aedes aegyptii	Yellow fever mosquito									high	human habitation	fresh water	good	high	high
Myrmecophilus americanus	Ant cricket	India	<2007							low	ant nests	ants	low	low	low
Plant diseases vectors parasites				Aruba	Bonaire	Curacao	Saba	St Eustatius	St Maarten						
Cactoblastis cactorum	Opuntia cactus moth											Opuntia	low		
Bemisia tabaci	White fly		1989									various crops			
Toxoptera citricida	Black Citrus aphid, Brown Citrus aphid		1989									citrus crops			
Cylas formicarius	sweet potato weevil		1990									sweet potato crops			
Papilio demoleus	Common lime butterfly	SE Asia	?	wind?						low	?	citrus crops	good	low	high
Thrips palmi	palm thrips		1994									palms			
Gynaikothrips ficorum	Cuban Laurel Thrips		1996									crops			
Phyllocnistis citrella	Citrus miner		1996									crops			
Macconellicoccus hirsutus	Pink/Hibiscus Mealy bug		1997									crops, natural vegetation			
Paracoccus marginatus	Papaya Mealy bug		2002									papaya crops			
Rhynchophorus ferrogineus	Red palm weevil		2008									palms			
Crypticerya genistae	White partridge pea bug		2009												
Aenolamia varia	Spittle bug		1986												
Schizotetranychus hindustanicus	Citrus hindu mite		2000									natural vegetation			
Aspidiotus destructor	Coconut scale		19th century									coconut tree			
Mionochroma vittatum	longhorn beetle	Venezuela	19-20th century									mahogany wood			
Thrips sp.?	Tabebuia plague	?	early 1990s									Tabebuia woodlands			
Fungi															
Claviceps africana	Sorghum ergot		2003									crops			
Fusarium of Palms			2005-2010									palms			
Ganoderma zonatum	Ganoderma butt rot of palms -											palms			
Gliocladium of palms			2005-2010									palms			
MLO's (Mycoplasma Like Organisms)															
Lethal Yellowing of Palms (LYdisease)												palms			
Papaya Bunchy Top (MLO)			early 1960									crops			
Papaya Ringspot Virus (PRSV-P)			2002									crops			

Preliminary list of Alert agricultural animal and plant pest species in Dutch Caribbean islands					
			Impacts	**Main entry threat**	**Principal threat**
Species	**common name**	**region of origin**	**ecol/econ**		
Molluscs					
Achatina achatina	Giant African Land snail	Africa	high	ornamentals	vegetation crops
Achatina marginata	Giant West African Land snail	Africa	high	ornamentals	vegetation crops
Limicoraria aurora	African land snail	Africa	high	ornamentals	vegetation crops
Insects					
Beetles and Weevils					
Xylebora glabratus	Redbay ambrosia beetle	Japan	high		natural
Rhynchephorus cruentatus	Palmetto weevil	Florida	high	ornamentals, wind	natural and landscaping plants
Scyphophorus acupunctatus	Agave weevil	South America	high	ornamentals, wind	natural vegetation
Sternochaetus mangiferae	Mango seed weevil	Indo-Burma	high	fruit imports	commercial crop
Mealybugs					
Hypogoecoccus pungens	South American cactus mealybug	South America	high	ornamentals	natural vegetation
Bees, Termites and Ants					
Apis mellifera scutellata	Africanized honey bee	Africa	high	wind	birds, animals humans
Coptotermes formosanus	Formosan subterranean termite	South China	high	furniture	trees and structures
Vespula squamosa	Yellow jacket wasp	N. America		container shipment	*animals humans*
Solenops invicta	Red fire ant	S. America	high	container shipment	nature, crops
Flies and mosquitos					
Bactrocera invadens	African fruit fly	Africa	?	fruit	crops
Cochliomyia hominivorax	New World screw–worm fly	S. America	high		livestock, pets, humans
Aedes albopictus	Asian Tiger mosquito	Asia	high	air traffic	birds, man
Dragonflies					
Crocothemis servilia	Crimson darter	E-SE Asia	*?*	wind	aquatic habitat pollinators
Butterflies					
Tuta absoluta	South American tomato pinworm			wind	crop
Ticks and mites					
Cochliomyia hominivorax	New World screw–worm fly	S. America	high	livestock for slaughter	livestock, humans
Raoiella indica	Red palm mite	Africa	high	wind	commercial landscaping
Amblyomma variegatum	Tropical bont tick	Senegal	high	pets, livestock	animals humans
Ixodes	Lyme disease ticks	N. Hemisphere	high	pets livestock	humans
Nematodes					
Bursaphelechus cocophilus	Red ring nematode	South America	high	coconuts	commercial crops