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INVASIVE ALIEN SPECIES IN THE DOMINICAN REPUBLIC: THEIR IMPACT AND STRATEGIES TO MANAGE INTRODUCED PESTS

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ABSTRACT: The increased exchange of agricultural goods and people has unleashed the spread of alien species in the Caribbean. The Dominican Republic, as well, has been burdened with the introduction of dozens of alien species, including a substantial number with high invasive potential. Some of these have caused significant economic losses to affected crops within intensive agro-ecosystems, and others have displaced native species, and/or interfered with the functioning of susceptible ecosystems. Herein we list about 50 cases of introduced agricultural pests including arthropods, molluscs, and plant pathogens causing fungal, bacterial, viral or other diseases. We briefly review selected examples with respect to their detection, impact and countermeasures taken. In most cases involving introduced alien arthropods, the lack of specialized antagonists, and/or the ineffectiveness of native antagonists have permitted rapid dispersal of the introduced pests. This has occurred in the cases of vectors of plant pathogens (aphids, and whiteflies), mealybugs, thrips, fruit flies, the coffee-berry borer, and recently the pigeon pea pod fly. Thus far, no introduced pests have been eradicated from the Dominican Republic. On the other hand, intentional or accidental introductions of antagonists of some introduced insect pests have resulted in dramatic population decreases of these alien species, often to levels well below economic-damage levels. This decrease has been achieved in the cases of the citrus blackfly, the citrus leafminer, the brown rice bug, and the papaya mealybug. Regarding the pink hibiscus mealybug, the combination of parasitoid species, probably introduced together with the pest, and the predacious mealybug destroyer already present since the 1930s, and the implementation of classical biocontrol have not permitted damage at levels comparable to those caused by this pest in the Lesser Antilles during the last decade.

INTRODUCTION

In the last 25 years, significant increases in the international exchange of travelers and agricultural goods have caused a surge in both the risk, and actual introduction, of exotic plant and pest species, especially plant pathogens and arthropods, into the Dominican Republic, which covers the two eastern thirds of Hispaniola. The main factors contributing to this surge include:

- an improved, but still not sufficiently effective, quarantine system;
- sharing the island with Haiti, a politically unsettled country with a deficient safeguarding system, and a long border porous to pests;
- the occurrence of tropical storms and hurricanes, which can spread certain introduced pests and plant pathogens after their introduction into the Caribbean region.

The main implications of the introduction of alien invasive species are as follows:

- Many are major pests that cause direct yield losses to crops, and/or reductions in quality of harvested products, and increased costs of production. Consequently, production of some

important crops has become unprofitable and unsustainable, and this has been accompanied with severe socio-economic distress. This situation occurred during the mid 1990s when the *Bemisia*-Geminivirus complex destroyed the production of tomatoes and other host crops.

- Loss of export markets. Alien pests often cause restrictions or bans on potentially infested or infected export products by countries that consider these pests or plant pathogens as quarantine-significant. These bans have severe economic implications to the producers, who risk the loss of competitiveness.
- Losses in biodiversity: In particular, invasive alien plant species tend to displace endemic and native species from protected natural areas.

Experience has shown that many introduced alien species become established, and in a relatively short period those with strong invasive potentials spread into agrarian or natural environments. Reports on introduced arthropods, plant pathogens, and invasive plant species seldom explain whether the pests were introduced deliberately, how the pests arrived, their countries of origin, their ports of entry, and their distribution. Often such information may be obtained only after these species have caused economic damage, or other serious problems. In many cases, the absence of specific antagonists has allowed highly damaging introduced alien species to spread rapidly throughout the country.

Examples of invasive alien plant species are presented in Tables 1 and 2. However, the problem of invasive species is enormous and complex, and this account does not treat many established alien invasive vertebrates (mammals, birds, reptiles, amphibians and fishes), nor plants, nematodes and other taxa. Many of the latter were introduced decades or even centuries ago, often intentionally, and their spread and negative impact have already been reported in other countries of the Caribbean.

Few records on the introduction of exotic plant species, and of the reasons for their often planned introduction are available. Most of the perennial species were introduced as fruit trees, ornamentals, reforestation to prevent soil erosion or to produce timber or fuel. Some species introduced centuries ago, now play an outstanding role in the native landscape, including the coconut palm (*Cocos nucifera* L., Palmaceae) from the southern Pacific, the tropical almond (*Terminalia cattapa* L., Combretaceae) in the coastal landscapes from Malaysia and Southern Asia, breadfruit trees (*Artocarpus altilis* (S. Park.) Fosb., Moraceae) in humid environments, and *Pinus caribaea* Morelet (Pinaceae) in mountain areas.

Some of the perennial alien species with invasive potential listed in Tables 1 and 2 are spreading into protected areas, and are displacing native endemic flora. The management of invasive plant species has been discussed recently with respect to protecting natural reserves. Nevertheless, special strategies for the management of those plant species in endangered environments either have not been implemented, or have been implemented only where they are problematic for annual and perennial crops and pastures.

Water hyacinth, *Eichhornia crassipes* (Mart.) Solms, is an economically serious problem in the Dominican Republic. It has invaded numerous aquatic environments, and has disrupted irrigation and navigation on rivers. Studies on the classical biological control of the water lily are planned with the support of the University of Puerto Rico. Successful classical biological control of *E. crassipes* would encourage similar thrusts against other weed species.

Numerous agriculturally significant arthropod pests and plant pathogens were introduced into the Dominican Republic and reported between 1975 and 2003 (Table 3).

IMPORTANT INTRODUCED PLANT PATHOGENS IN THE D.R.

Among 37 listed agricultural pests listed in Table 3, the plant pathogens most frequently reported as causes for severe diseases in agricultural crops in the Dominican Republic belong to the fungi (6), bacteria (2), viruses (4) and phytoplasmas (1).

Selected diseases and plant pathogens are discussed below.

a. Coconut Lethal Yellowing Disease (CLYD, Phytoplasma) has been reported in the Caribbean since the 1960s (Jamaica, Florida). It was reported in the D.R. by Schmutterer (1990), and was re-confirmed in 1995. It is caused by a phytoplasma transmitted by the 'palm cixiid', *Myndus crudus* (van Duzee) (Hemiptera [Auchenorrhyncha]: Cixiidae) as vector. To meet this danger, all detected infected and surrounding plants were destroyed in 1995. International authorities have recognized the commercial coconut growing regions in the Northeast as a disease-free area.

b. Bean Golden Mosaic Virus (BGMV, Begomovirus) was reported in 1978. This whitefly (*Bemisia tabaci*) - borne viral disease has been considered as a serious limiting factor for bean production in the D.R., the Caribbean, Central America and Florida. Numerous studies have focused on managing the whitefly/virus complex, but only the selection and introduction of tolerant varieties has permitted sustainable bean production. Since more than 10 years ago, the National IPM Program (SEA-JAD) has been implementing a host plant-free period in the most important tomato and bean growing areas, especially in the irrigated valleys of the south, southwest and northwest.

c. *Peronospora hyoscyami* de Bary (Peronosporales), blue mold of tobacco, or tobacco mildew was identified in 1981. This fungal disease was the main cause for the reduction of the tobacco-growing area. Monitoring systems were implemented in the 1980s, and effective chemical control has reduced the importance of the disease.

d. *Hemileia vastatrix* Berk. & Br. (Uredinales), coffee rust was introduced in about 1989. This fungal disease spread quickly throughout lowland coffee plantations. Although initially devastating, coffee rust with its economic impact has been reduced through strategic use of chemical controls.

e. Citrus Tristeza Virus (CTV, Closterovirus) was reported in 1990 by R.F. Lee. Etienne et al. (1992) identified its most efficient vector *Toxoptera citricida* (Kirkaldy). The main problem is that most citrus trees in plantations are grafted onto susceptible sour orange rootstocks. Management of the disease is based on grafting onto tolerant rootstocks, i.e., *Citrus* 'Volkameriana', Carrizo, and others. A program to produce CTV-free plants has been initiated recently with co-operation between (Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD).

f. Tomato Yellow Leaf Curl Virus (TYLCV, Begomovirus). This whitefly (*B. tabaci*)-borne virus, identified as TYLCV-Israeli strain, was observed first in 1991 in single tomato plants. This was the first reported introduction of this virus in the Western hemisphere (Nakhla et al,. 1994; Polston et al., 1994). Since 1992 this virus has caused devastating yield losses. Seminal studies on the epidemiology, host plant range of the virus and its vector have been conducted (see silverleaf whitefly). The system to manage this problem includes the area-wide use of systemic insecticides and host-free periods.

g. *Ralstonia solanacearum* (E.F. Smith) (Proteobacteria), this bacterial wilt of potato bacterium was confirmed in the D.R. in 1994 by P. Jorge and contributors (unpublished). Only limited management is possible at this time because of low quality plant propagation material. A program to produce certified potato planting material is planned by the IDIAF. Several strains are present in the country, some of which also attack tomato.

h. *Mycosphaerella fijiensis* Morelet (Ascomycetes: Mycosphaerellales), Black Sigatoka of *Musa* species was identified in 1996 and confirmed by scientists at CIRAD, Montpellier. This severe fungal disease destroys leaves of banana and plantain. Management is based on removal of infected leaves, fungicide applications, limited biological and climatic forecasting, and limited planting of tolerant hybrids (FHIA 20, 21, 25) (T. Polanco and P. Jorge 2002, unpublished). A nationwide extension program to meet this acute threat has been implemented by SEA.

i. Bean Common Necrotic Mosaic Virus (BCNMV, Potyvirus) was identified in 2000 in San Juan de la Maguana Valley, the main bean-producing area. Bean seed lots are tested to prevent the spread of the disease through infected seeds, and molecular genetic studies are being carried out by G. Godoy de Lutz (IDIAF).

j. Banana Streak Virus (BSV, Badnavirus) was identified in 2001 and confirmed by scientists at CIRAD – Montpellier, France. The distribution and incidence of the virus are still limited, according to a survey begun in 2001 by R.T. Martinez (IDIAF).

IMPORTANT PLANT PATHOGENS WITH POTENTIAL TO ENTER THE DOMINICAN REPUBLIC

If introduced into the D.R., the pathogens discussed below would be highly damaging.

a. *Ralstonia solanacearum* (E.F. Smith) (Proteobacteria), bacterial wilts, caused by diverse strains of this pathogen are present in the Caribbean area, and could threaten tomato and flower production. Uncharacterized biovar I strains with a wide host range including *Anthurium andreanum*, *Heliconia caribaea*, *Canna indica*, cucurbits, and several weeds have been reported from Martinique (Mian et al., 2003).

b. Tomato spotted wilt virus (TSWV, Tospovirus) has a wide host–plant range. Its most efficient vector, the thrips *Frankliniella occidentalis* (Pergande) is already present, but the TSWV has not been reported in the D.R.

c. *Liberobacter asiaticum* (L.) Jack (Proteobacteria), cause of 'citrus greening disease' (CGD) is a serious malady. It has not been reported in the Caribbean. Its most efficient vector, the psyllid *Diaphorina citri* Kuwayama, is already present (Abud, 2001).

d. Leprosis of *Citrus* (Rhabdovirus) and the associated mite vectors, *Brevipalpus* spp. complex (Acari: Tenuipalpidae), have caused significant economic losses in Brazil, Argentina and Panama. Leprosis was present in Florida, but has not been reported since 1961 (Childers et al., 2002).

e. *Moniliophthora roreri* (Ciferri) H.C. Evans *et al.* (Basidiomycetes) causes 'frosty pod rot'. It has caused more than 60% loss of the cocoa crop in Ecuador and Costa Rica.

f. *Crinipellis perniciosa* (Stahel) Singer (Basidiomycetes) causes 'witches broom disease' of cocoa (WBDC). It is present in South America.

The absence of the latter two very severe diseases on Hispaniola is one of the main reasons that the D.R. is the leading worldwide producer of organic cocoa.

IMPORTANT INTRODUCED ARTHROPODS AND OTHER PESTS IN THE D.R.

a. *Bemisia tabaci* (Gennadius) (Hemiptera [Sternorrhyncha]: Aleyrodidae), Biotype A, sweet potato whitefly, was reported in 1975. It showed a wide host range, and caused severe yield losses in bean fields due to direct damage, and as the vector of the Bean Golden Mosaic virus (BGMV). Improved chemical control, and the use of tolerant varieties developed by CIAT and in a USAID program minimized this problem for many years. Biotype A of *B. tabaci* has not

been found since 1994, because it appears to have been displaced entirely by the **Biotype-B**, also known as ***B. argentifolii*** (Bellows and Perring) (Serra et al., 1994b; 1996).

b. *Trialeurodes vaporariorum* Westwood (Hemiptera [Sternorrhyncha]: Aleyrodidae), the greenhouse whitefly, was reported in 1978 in mountain valleys. This whitefly has a wide host range. Studies on natural enemies have been achieved. Parasitoids have been released and are established. Nevertheless, the high spray frequencies employed in intensively managed vegetable growing areas have induced high levels of resistance to insecticides, and have prevented biological control.

c. *Eriophyes guerreronis* Keifer (Acari: Eriophyidae), the coconut flower and nut mite, was identified in 1979. It has spread throughout the coconut growing areas, and it degrades coconut quality. Fungal pathogens associated with the mite have been detected. Recently, studies were undertaken on the management of the pest.

d. *Thrips palmi* Karny (Thysanoptera: Thripidae), the melon thrips, was identified in 1988 on eggplant. It attacks several cucurbits, pepper and other vegetables. From 1989 to 1996 the U.S. authorities banned of importation of Chinese vegetables from the D.R. because of impermissible pesticide residues and the occurrence of *T. palmi,* a quarantine pest. Consequently, an IPM program was implemented from 1991-92 based on monitoring, and cultural and postharvest measures, and in 1997 the ban was lifted.

e. *Bemisia tabaci* (Gennadius), Biotype B, or *B. argentifolii* Bellows & Perring (Hemiptera [Sternorrhyncha]: Aleyrodidae), the silverleaf whitefly, was identified in 1988. Unlike Biotype A, it reproduces on tomato. Initially Biotype B caused severe damage as a result of sap sucking, the growth of sooty mold on discharged honeydew, and uneven ripening in tomato, or the silvering of leaves of cucurbits. Between 1989 and 1995 losses to the tomato industry in D.R. were estimated at US$ 60 million (Polston and Anderson, 1997). Conventional chemical control was not effective, and even caused excessive increases in populations. On the other hand the management of the whiteflies was possible by the use of selective insecticides (Serra, 1992). In 1991, a geminivirus, TYLCV (see above) was detected in tomato fields. With its dissemination, yield losses increased catastrophically. Seminal studies on the host range of both the vector and the virus, as well as chemical, biological and integrated management have been achieved (Serra et al., 1994a, 1994b, 1996). An IPM program including legal measures (an annual 3-month host-crop-free period enforced by PNMIP-SEA-JAD), tolerant varieties, the use of protected nurseries, and systemic insecticides was implemented. It greatly reduced yield losses. Nevertheless, recently the importance of the complex has again increased.

f. *Rhizoglyphus robini* Claparede (Acari: Acaridae), the bulb mite, was reported in 1989 on garlic in a mountain valley of Constanza. This species was probably introduced with bulbs from China. Chemical control has not been very effective. In the 1990s a program (FST-Ciba Geigy) focused on reducing the spray frequency, and on the use of selective pesticides. Studies have been conducted on infestations in fields and in storage, and these included comparisons of conventional, botanical and selective pesticides (Serra et al., 2003).

g. *Pseudacysta perseae* (Heidemann) Blatchley (Heteroptera: Tingidae), the avocado lacebug, was reported in 1990. Causing defoliation, the pest has since spread throughout all avocado growing areas. Surveys for effective natural enemies have not been fruitful. Extension work has been achieved by the National IPM Program. The lacebug is commonly associated with *Colletotrichum* sp. (P. Jorge and R. Mendez, unpublished).

h. *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), the western flower thrips, was identified in 1990. This thrips threatens the flower industry, since it is an efficient vector of the Tomato Spotted Wilt Virus (TSWV). TSWV has a wide host-plant range, but has not been reported in the D.R.

i. *Pomacea canaliculata* (Lamarck) (Stylomatophora: Ampullaridae), the golden or Channeled snail, was initially misidentified in 1991 as *Ampularia* (syn. *Pomacea*) *glauca* (L.), the Apple snail. The snail probably was introduced to clear algae from ponds, and subsequently escaped into irrigated-rice fields, spread through the irrigation systems, and now damages young plantings of rice. In 1996 the Ministry of Agriculture started a chemical control program, and in 1997 the Ministry offered a bounty for snails and snail eggs, but this latter approach failed. In 2001 a program combining trapping and chemical control was initiated.

j. *Aleurocanthus woglumi* Ashby (Hemiptera [Sternorrhyncha]: Aleyrodidae), the citrus blackfly, was reported in Haiti in the 1930s by Ashmead. Subsequently heavy infestations of the citrus blackfly were reported in Santo Domingo (Abud, 1992). The problem was overcome through the introduction of parasitoids, their mass rearing and successful releases by the JAD, so that now the pest is unimportant.

k. *Toxoptera citricida* Kirkaldy (Hemiptera [Sternorrhyncha]: Aphididae), the brown citrus aphid, was identified by Etienne et al. (1992). This aphid is considered the most efficient vector of the citrus tristeza virus (CTV) present in the D.R. A parasitoid, *Aphidius colemanii* Viereck, was imported from Argentina through Florida, but has not been recovered. However efficient parasitoids are present.

l. *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), the citrus leafminer, was identified in 1994. An IPM program consisting in extension work to avoid spraying has been implemented. A survey of native parasitoids has been accomplished (Tavares, 2000). Effective parasitoids are present and are widely found.

m. *Varroa jacobsoni* Oudemans (Acari: Varroidae), the Varroa mite, was identified in 1995. The Varroa mite has caused serious losses to the national production of honey and other bee products. The situation has been improved through a program consisting in extension work and chemical control conducted by the Animal Health Dept., Redapi/CEDAF.

n. *Hypothenemus hampei* Ferr. (Coleoptera: Scolytidae), the coffee berry borer, was identified near Cotuí in 1995. Heavy yield losses have been limited to coffee grown at low altitudes. Biological, manual and chemical control has been implemented. A trapping system (Brocap®-CIRAD) has been tested in combination with manual practices (Pérez, 2003).

o. *Tibraca limbativentris* (Stål.) (Heteroptera: Pentatomidae), the rice stalk stinkbug, was re-identified in 1997. It might have been present since the 1980s (Pantoja, pers. com.). A survey of natural enemies was conducted, and was followed by the successful implementation of biological control with mass releases of a native egg parasitoid (*Telenomus* sp.) by the PNMIP-SEA-JAD.

p. *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera [Sternorrhyncha]: Pseudococcidae), the papaya mealybug, was identified in 1997 on papaya, mandioca and ornamentals. In 2001, a successful program of classical biological control with 4 imported parasitoids was carried out jointly by USDA-APHIS, the National IPM Program, and SEA-JAD. Within 6 months the density of the pest's populations dropped by more than 95% (Meyerdirk and De Chi, 2003).

q. *Steneotarsonemus spinki* Smiley (Acari: Tarsonemidae), the rice tarsonemid mite, was identified in 1998. It was probably introduced from Cuba. The mite appears associated with the fungal pathogen, *Sarocladium oryzae* (Sawada) W. Gams & D. Hawksworth. Research on tolerant varieties and chemical control has been carried out. As a consequence, a tolerant variety was planted in more than 80% of the wetland-rice areas. New materials are being tested, but the problem still persists.

r. *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae), the pigeon pea pod fly, was identified in 2000. This fly of Asian origin has already reached nationwide dissemination. Surveys showed damage levels exceeding 50% in the absence of effective natural enemies.

Studies on chemical control are being undertaken by the IDIAF (Cedano et al., 2003; Serra et al., 2003). Since the profitability levels of the pigeon pea crop are low, and since many producers belong to the subsistence sector, the implementation of classical biological control has been requested. Consequently, foreign exploration for parasitoids will be carried out in Asia during 2003 by USDA-APHIS.

s. *Diaphorina citri* Kuwayama (Hemiptera [Sternorrhyncha]: Psyllidae), the Asiatic citrus psyllid, was reported in 2001. This species is a potential vector of the 'citrus greening disease' (CGD), which is still absent from the Caribbean. Parasitoids and fungal pathogens of this vector have been detected.

t. *Contarinia maculipennis* Felt (Diptera: Cecidiomyiidae), the 'blossom midge', was identified in 2001. This midge is widely distributed, and attacks orchids, tomato, *Hibiscus* spp., and other ornamentals. It is already widely distributed throughout the country.

u. *Maconellicoccus hirsutus* (Green) (Hemiptera [Sternorrhyncha]: Pseudococcidae), the pink hibiscus mealybug, was reported in 2002. This mealybug has a wide host range, and has been very destructive on other Caribbean islands. Studies have been conducted on natural control by an established predator and introduced parasitoids, population dynamics, host plant range, and geographic distribution (Nuñez et al., 2003; Serra et al., 2003). A successful program of classical biological control with two parasitoids was started in August 2002, and has since been monitored by APHIS, SEA, National IPM Program, IDIAF-UNPHU, and UASD.

v. *Cyrtophora citricola* (Forsköl) (Aranae: Araneidae), the tropical tent-web spider, was identified in 2002. This spider originated in southern Africa, and spread through the Middle East and Mediterranean. It occurs on *Citrus*, other trees and shrubs, and is spreading throughout the D.R., Florida, Venezuela and Colombia. Observations to understand the cause of the damage and how the spider is involved have been initiated by Serra. The spider produces indirect damage through a dense web that can kill the host plants. Chemical control by localized spraying is effective, but risks disturbance of the ecosystem in perennial fruit orchards.

LESS WELL KNOWN INTRODUCED ARTHROPOD PESTS IN THE D.R.

A number of arthropod pests that probably entered the Dominican Republic during the last three decades, but which are poorly known, are described below.

a. *Tetranychus* sp. (Acari: Tetranychidae), an unidentified spider mite was detected in the Northwest. It covers tomato and other plants with an extra-dense web (Serra et al., 1994b).

b. *Eriophyes hibisci* (Nalepa) (Acari: Prostigmata: Eriophyidae) attacks *Hibiscus* spp., and is disseminated in many parts of the country (determined by M. Pellerano, pers. commun.).

c. *Eriophyes annonae* Keifer (Acari: Eriophyidae) is found on *Annona* spp.

d. *Anastrepha obliqua* (Macq.) (Diptera: Tephritidae), the West Indian fruit fly, attacks guava, mango, and other fruits.

e. *Anastrepha suspensa* (Loew) (Diptera: Tephritidae), the Caribbean fruit fly, has been trapped by Cuevas et al. (2002) and Abud (unpubl. data). It infests guava, mango, *Eugenia* spp., and tropical almond (*Terminalia cattapa L.*).

f. *Anastrepha dissimilis* Stone (Diptera: Tephritidae) has been trapped by Cuevas et al. (2002) and Abud (unpubl. data). It attacks the passionfruits, *Passiflora edulis* and *P. quadrangularis*.

g. *Anastrepha ocresia* (Walker) (Diptera: Tephritidae) has been trapped by Cuevas et al. (2002) and Abud (unpubl. data). It attacks sapodilla, *Manilkara zapota* (L.) van Royen, *Achras zapota* (L.).

h. *Anastrepha* sp. (syn. *hambletoni*?) (Diptera: Tephritidae) has been trapped (Cuevas et al., 2002; and Abud, unpubl. data). It attacks cashew, *Anacardium occidentalis*.

i. *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae), the American serpentine leafminer, attacks many vegetables, flowers and ornamental plants. Its introduction has not been reported, however the pest probably has occurred in the D.R. since the late 1970s.

j. *L. huidobrensis* (Blanchard) (Diptera: Agromyzidae), the pea leafminer, has been reported by Abud (1992).

k. *Hypsipyla grandella* Zeller (Lepidoptera: Pyralidae), the mahagony shoot borer, has been causing damage to *Swietinia* and *Cedrela* for years.

l. *Cactoblastis cactorum* (Bergroth) (Lepidoptera: Pyralidae), the cactus moth, has been present in the D.R. at least since 1970. It has been purposely released in the Caribbean since the 1950s for biocontrol of *Opuntia* spp., a forage. Studies on natural enemies and biocontrol have been conducted by the IDIAF (Wagner and Colón, 2002).

m. *Gynaikothrips ficorum* (Marchal) (Thysanoptera: Phlaeothripidae), the Cuban laurel thrips. Its population exploded into a nation-wide outbreak on *Ficus benjamina* in 2002. Apparently the pest has been present for many years.

n. *Myndus crudus* (van Duzee) (Hemiptera [Auchenorrhyncha]: Cixiidae) is a vector of the coconut lethal yellowing disease (CLYD). It has not been reported to be established, but this has not been confirmed recently.

o. *Planococcus lilacinus* (Cockerell) (Hemiptera [Sternorrhyncha]: Pseudococcidae). This mealybug has been reported to be present in the D.R. (Miller and Miller, 2001). Nevertheless its presence has not been confirmed by local authorities. It has the potential to cause economic losses to cocoa, citrus, guava and mango.

p. *Oxycarenus hyalinipennis* (Costa) (Heteroptera: Lygaeidae), the cottonseed bug, was reported in the D.R. by Slater and Baranowski (1994), but no local confirmation is available.

INVERTEBRATE PESTS WITH POTENTIAL TO ENTER THE D.R. IN THE NEAR FUTURE

a. African giant snail (*Achatina fulica* (Bowdich), Stylomatophora: Achatinidae) is present in Guadeloupe, Martinique and other islands in the southern Caribbean. It destroys native snail species through competition, but not by preying on them.

***b. Amblyomma variegatum* (Fabr.) (Acari: Ixodidae)**, the 'tropical bont tick', is an important vector of heart water disease (tick-borne rickettsial disease of ruminants) in Africa. It is present on Guadeloupe, Martinique and other islands in the Caribbean (Pegram and Indar, 2003).

c. *Planococcus minor* (Maskell) (Hemiptera [Sternorrhyncha]: Pseudococcidae). This mealybug has a wide host range, and the potential to cause economic losses to the cocoa industry. It is present in the Caribbean, and has been reported to have entered Haiti (Miller et al., 2002).

d. *Aulacaspis yasumatsui* Takagi (Hemiptera [Sternorrhyncha]: Diaspididae), the 'sagopalm scale', or *Cycas aulacaspis* scale, originated in Asia. It is present in Florida and Puerto Rico, where it has caused very severe damage to cycads (Pena and Baranowski, 1999; Aixa Ramírez, pers. com.).

e. *Paratachardina lobata lobata* (Chamberlin) (Hemiptera [Sternorrhyncha]: Kerriidae), the 'lobate lac scale', is present in the Bahamas and Florida. It attacks more than 150 woody species (Howard, 2003).

f. *Rhynchophorus palmarum* (L.) (Coleoptera: Curculionidae), the 'South American palm weevil', attacks coconut palms and palms belonging to the genera *Elaeis*, *Livistonea* and *Phoenix*. The weevil vectors the nematode, *Rhadinaphelenchus cocophilus*, which causes the serious red-ring disease of coconut palms (RDCP) (Schmutterer, 1990).

g. *Rhinostomus barbirostris* F. (Coleoptera: Curculionidae), the 'bearded coconut weevil' attacks several palm species, and is an effective vector of the RDCP (Franqui, 2003).

h. *Sternochetus mangiferae* (F.) (Coleoptera: Curculionidae), the 'mango seed weevil', is already present in the southern Caribbean.

i. *Anthonomus eugenii* Cano (Coleoptera: Curculionidae), the 'pepper weevil', is a serious pepper pest present in Florida, southwestern U.S.A. and Puerto Rico.

j. *Stenoma catenifer* Walsh (Lepidoptera: Oecophoridae), the 'avocado seed moth', is present in northern South America, Panama, and Mexico (ESA, 2001).

k. *Anastrepha ludens* (Loew) (Diptera: Tephritidae), the 'Mexican fruit fly', is already present on Grenada and other islands.

l. *Bactrocera carambolae* Drew & Hancock (Diptera: Tephritidae), the 'carambola fly', is present in northeastern South America.

m. *Bactrocera* spp. (Diptera: Tephritidae). Of special concern are the 'oriental fruit fly', ***B. dorsalis*** Hendel, and the melon fly, ***B. cucurbitae*** Coquillett.

n. *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), the 'Mediterranean fruit fly', is established throughout Central America, and has to be considered one of the most dangerous quarantine pests, because of implications for fruit exportation to the U.S.A.

CONCLUSIONS AND DISCUSSION

During recent years, establishment of alien invasive species in the Dominican Republic has been reported with increased frequency, especially arthropods and plant pathogens. Unfortunately, the time of arrival of a relatively high number of these species, especially arthropods, cannot be ascertained. We assume that the introductions of many of them occurred long before their populations reached outbreak levels. The 37 most important exotic pest species reported between 1975 and 2002 (Table 3) belong to the following taxonomic groupings:

a) 23 arthropod species: 16 insect species: 8 Homoptera spp., 2 Hemiptera spp., 2 Thysanoptera spp., 2 Diptera spp., 1 Coleoptera sp. and 1 Lepidoptera sp.; 7 arachnid species: 6 mite species, and 1 spider species;
b) 1 mollusc species;
c) 13 plant pathogens: 5 fungi species, 2 bacterial species, 1 phytoplasma, 5 viruses

In addition to this list, more than a dozen arthropod species were mentioned as introduced, but no information on the year or period of entry or official confirmation of their presence was available. In general, there has been an increase in the number of reported exotic pests during the last decade. This is partly due to improved quarantine, taxonomic and diagnostic services for quick detection, backed by regional pest alert services (APHIS, CABI, IICA, etc.). On the other hand, the movement of alien pests into and within the Caribbean area, and risks of their accidental introduction, have increased because of the steadily growing importance of tourism and international trade of agricultural products. This problem can be expected to intensify further, especially as the Free-Trade Area of the Americas Agreement and other agreements with countries on other continents are concluded during the coming years.

Measures to stem the introduction of additional invasive pest species. The superiority of area-wide pest suppression over conventional field-by-field suppression, with the power of area-wide pest management as a phytosanitary measure, has been asserted by Klassen et al. (2002), citing the works of different authors (Meyerdirk, 1999; Klassen, 2000; Lindquist and Mumford, 2000), as well as by Griffin (2000). For the U.S.A. this means a greater shift to offshore strategies (a. prevention; b. preclearance) to supplement in-country strategies (a. exclusion; b. detection/ containment/ area-wide pest management or eradication; c. conventional Integrated

Pest Management; d. biological control) for meeting exotic pest threats (Klassen et al., 2002). The Dominican Republic, as well as many other countries of the Caribbean area, cannot aspire to build up such an effective system to assure exclusion of invasive pest species, as the one presented by Klassen et al. (2002), especially with respect to implementing its own offshore strategy. Nevertheless, it is necessary to revise existing protocols for strengthening possibly deficient aspects of the in-country strategy, and to find ways to support regional efforts.

Various topics on invasive species across the islands of the Caribbean have been selected and discussed during the last month in the form of an electronic workshop. The workshop was part of a new regional initiative supported by The Nature Conservancy and implemented by CAB International, as well as other national or regional organizations including the Inter-American Institute for Cooperation on Agriculture (IICA), Caribbean Agricultural Research and Development Institute (CARDI), CIRAD, University of Florida, University of Puerto Rico, and forums, such as the present USDA/T-STAR sponsored Symposium, including neighboring regions as northern South America, Central America and the southern United States. These and other more specific topics should be debated on a national level in the Dominican Republic by competent authorities, and by affected and interested sectors of the society in order to develop a national agenda, which should include the following topics:

- Characterization of the threats and impact of invasive species.
- Prioritization of invasive species on a national and regional level concerning food production, biodiversity, tourism and marine health.
- Examination and assessment of existing legislation on the management of invasives, identification of gaps, and opportunities for improvement.
- Development of recommendations for improvements and opportunities for partnerships to reduce the threat of invasives, especially those with multiple-site impact.

Specifically, discussions should focus on ways to do the following:

- Strengthen the quarantine systems of the Dominican Republic and Haiti, and improve cooperation between the two countries;
- Strengthen the forecasting system for the Caribbean through a wide participative network;
- As part of a regional effort, strengthen support of biological control programs and foreign exploration for natural enemies of potential pests before the pests have entered the Region.

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Table 1. Examples of alien invasive herbaceous plant species established in the D.R.

Family and -Genus species	Introduced as	Status (region)
Apocynaceae:		
-*Catharanthus roseus* (L.)	ornamental?	coastal areas (S)
-*Cryptostegia grandiflora* (Roxb.)	ornamental?	invading dunes (Baní, S)
-*C. madagascariensis* Boj.	ornamental?	invasive (Azua, S);
Asteraceae:		
-*Erechtites hieracifolia (L.)*	medicinal?	
Balsaminaceae:		
-*Impatiens walleriana* Hook.	ornamental	invading coffee at higher altitudes
Poaceae:		
-*Echinochloa crus-galli* L.	with rice seeds	intractable weed in rice fields
-*E. crus-pavoni* (H.B.K.)	With rice seeds	very invasive, aquatic environments
-*Melinis minutiflora* Beauv.	forage (C)	very invasive in crops (S)
-*Themeda quadrivalvis* (L.) Ktze.	?	very invasive (S)
Polygonaceae:		
-*Antigonon leptopus* H. & A.	ornamental	invasive in dry areas (S-SW)
Pontederiaceae:		
-*Eichhornia crassipes* (Martius) Solms	accidental, ornamental?	very invasive, aquatic environments
Nephrolepidiaceae (ferns):		
-*Nephrolepis multiflora* (Roxb.) Jarret	ornamental?	very invasive in pastures

Abbreviations: Regions: C, Central; N, Northern; S, Southern; W, Western; E, Eastern; SW, Southwestern; and NE, Northeastern.

Table 2. Important alien invasive tree and shrub species established in the D.R.

Family and -Genus species	Introduced as	Status (region)
Bignoniaceae:		
-*Spathodea campanulata* Beauv.	ornamental tree	very invasive in humid secondary vegetation (N, NE)
Leguminosae-Mimosoideae:		
-*Acacia mangium* Willd.	wood, reforestation	starting to invade
-*Albizia lebbeck* (L.) Benth.	ornamental tree	starting to invade
-*A. procera* (Roxb.) Benth.	?	invasive in pastures, as in P.R.
-*Calliandra calothyrsus* Meisn.	~1985, forage, living barrier	very invasive in humid regions
-*Leucaena leucocephala* (Lam.) De Wit	cv. K24+K28 for reforestation	very invasive in dry areas (S)
Leguminosae-Papilionoideae:		
-*Flemingia strobilifera* (L.) R. Br.	1980s: ornamental?	very invasive in pastures (N, NE)
Meliaceae:		
-*Azadirachta indica* (A. Juss.)	1980s: reforestation, botanical insecticide	starting to be invasive in dry forests (Haiti, *Prosopis*)
Moraceae:		
-*Castilla elastica* Cerv.	?, provides a gum	very invasive in humid forests (NE)
Myrtaceae:		
-*Syzygium jambos* (L.) Alst.	fruit tree	invades shores of creeks in the 'Cordillera Central'
Rubiaceae:		
-*Morinda citrifolia* L.	uncertain	very invasive in coastal areas (E)
-*Vangueria madagascariensis* Gmel.	fruit tree, medlar	invasive in humid areas
Verbenaceae:		
-*Gmelina arborea* Roxb.	reforestation, ornamental.	invasive in humid areas

Table 3. Examples of important agricultural arthropod pests and plant pathogens reported in the Dominican Republic during the last three decades.

Year	Pests/Plant Pathogens	Common English name	Important host plants
1975	*Bemisia tabaci* 'Biotype A'	Sweetpotato whitefly	vegetables, ornamentals, vectors BGMV
1978	BGMV (begomovirus)	Bean Golden Mosaic Virus	bean, leguminous and other weeds
1978	*Trialeurodes vaporariorum*	Greenhouse whitefly	bean, vegetables, vectors begomovirus
1978	*Rhizoglyphus robini*	Bulb mite	garlic, onion, flowers with bulbs
1979	*Eriophyes guerreronis*	Coconut flower & nut mite	coconut palm
1979	*Puccinia melanocephala*	Sugarcane rust	sugarcane
'80's	*Polyphagotarsonemus latus*	Broad mite	*Capsicum* spp., citrus + other crops
1981	*Erwinia carotovora*	Blackleg of potato	potato and other vegetables
1981	*Peronospora Hyoscyami*	Blue mold of tobacco	tobacco
1987	*Sclerophthora macrospora*	Downy mildew of corn	corn
1988	*Bemisia tabaci* 'Biotype B'	Silverleaf whitefly	+500 hosts, vectors begomoviruses
1988	*Thrips palmi*	Melon thrips	eggplant, pepper, oriental veget., etc.
1989	*Hemileia vastatrix*	Coffee rust	lowland coffee plantations
1990	CTV (Closterovirus)	Citrus Tristeza Virus	citrus species (orange + Persian lime)
1990	*Pseudacysta perseae*	Avocado lacebug	avocado
1990	*Frankliniella occidentalis*	Western flower thrips	flowers, vegetables, vector TSWV°
1991	TYLCV (Begomovirus)	Tomato Yellow Leafcurl Virus	tomato, tobacco, bean, weeds
1991	*Pomacea canaliculata*	Apple snail	irrigated rice
1992	*Aleurocanthus woglumi*	Citrus blackfly	*Citrus* spp.
1992	*Toxoptera citricida*	Black citrus aphid	citrus trees, vector CTV
1993	*Tetranychus* sp.	Spider mite	tomato
1994	*Ralstonia solanacearum*	Bacterial wilt of potato	potato
1994	*Phyllocnistis citrella*	Citrus leaf miner	*Citrus* spp.
1995	CLYD (Phytoplasma)	Coconut Lethal Yellowing Dis.	disease of coconut palm
1995	*Hypothenemus hampei*	Coffee berry borer	coffee
1995	*Varroa jacobsoni*	Varroa mite	honey bees
1996	*Mycosphaerella fijiensis*	Black Sigatoka	banana and plantain
1997	*Tibraca limbativentris*	Brown rice bug	rice
1997	*Paracoccus marginatus*	Papaya mealybug	papaya, mandioca, ornamentals, etc.
1998	*Steneotarsonemus spinki*	Rice tarsonemid mite	rice
2000	BCNMV (Potyvirus)	Bean Comm. Necrot. Mosaic V.	beans
2000	*Melanagromyza obtusa*	Pigeon pea pod fly	pigeon pea
2001	BSV (Badnavirus)	Banana Streak Virus	banana and plantain
2001	*Diaphorina citri*	Asiatic citrus psyllid	citrus trees, vector CGD°
2001	*Contarinia maculipennis*	Blossom midge	orchids, tomato, ornamentals
2002	*Maconellicoccus hirsutus*	Pink hibiscus mealybug	*Hibiscus* spp., >200 spp.
2002	*Cyrtophora citricola*	Tropical tent-web spider	trees and shrubs, incl. *Citrus* spp.

° TSWV and 'Citrus Greening Disease' are not present in the D.R.