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UPDATE ON INVASIVE SPECIES INITIATIVES IN THE DOMINICAN REPUBLIC

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ABSTRACT: Serra *et al.* (2003) reviewed the status of invasive species (agricultural pests including arthropods, plant diseases and plants) introduced into the Dominican Republic (DR) in recent decades and also listed species with potential to be introduced. Very recent introductions include the lime swallowtail, *Papilio demoleus* (Lepidoptera: Papilionidae), native to Asia, which since its detection at the eastern end of Hispaniola has spread over DR's citrus-growing areas in the eastern and central regions and has reached those in the southwest. Recent invasive species initiatives by various scientists in the DR include: (1) establishment of the IABIN database for the DR, (2) convening of the Vth Caribbean Biodiversity Symposium, (3) a program to detect exotic fruit flies (4) a survey on distribution of reported fruit-fly species and their host plants, (5) evaluation of attractants and traps for fruit flies, (6) the emergence of parasitoids from several fruits, especially of mangos and *Spondias* spp., (7) several research activities on quite damaging invasive arthropod pest species such as the pigeon-pea pod fly (*Melanagromyza obtusa*), including surveys on damage, distribution of the pest and its natural enemies, trapping, host-plant range, chemical control and varietal responses. Due to the absence of effective parasitoids in pigeon pea plantings, it is necessary to implement classical biological control. However, the first introduction of specimens of biocontrol agents from Australia for quarantine purposes and reproduction failed. The rice spinky mite (*Steneotarsonemus spinki*), after having been tolerable for several years, has resumed causing serious damage to rice in association with fungal diseases. An IPM proposal for rice is being submitted by the IDIAF. The tropical tent-web spider (*Cyrtophora citricola*), a pest of citrus and other fruit trees, has become widespread on Hispaniola. The presence of coconut lethal yellowing disease in Hispaniola was reconfirmed by PCR in 1997. Although *Myndus crudus*, its known vector, has not been detected, the disease has slowly moved eastward along the northern coast toward the main coconut production areas. Some of the most important invasive species threats to the DR and the countries and/or areas in the region in which they are found are listed. Also summarized are 441 pest interceptions on 24 commodities shipped (Jan., 2003-Oct., 2005) from the DR to U.S. ports of entry (incl. Puerto Rico and the U.S. Virgin Islands), many being host-associated. Also included are insects detected, probably as 'hitchhikers' on avocado shipments in maritime ports of the U.S.A., and species of arthropods and plant diseases reported on commodities imported from the DR. A review of the relative importance of different regions of the Americas as sources of quarantine pests on various commodities transported by airplanes to the U.S.A. suggests that the probability per aircraft flight that invasive species will be transported to the USA from the DR and the West Indies is less than from Central America.

KEY WORDS: lime swallowtail, *Papilio demoleus,* IABIN data base, tropical fruit flies, pigeon pea pod fly, *Melanagromyza obtusa*, rice spinky mite, *Steneotarsonemus spinki,* coconut lethal yellowing, area wide mitigation, interception data

RESUMEN: Serra *et al.* (2003) presentaron un recuento sobre especies invasivas que fueron reportadas como plagas agrícolas (artrópodos, patógenos y plantas) durante las pasadas décadas y una lista de especies con potencial a ser introducidos al país. Como especie de reciente introducción, la 'Cola de golondrina de la Lima', *Papilio demoleus* (Lepidoptera: Papilionidae) de origen asiático fue reportada por Guerrero *et al.* (2004). Un sondeo demostró que desde su detección cerca de Punta Cana, en el extremo oriental, en un lapso de pocos meses, la especie se había desiminado en las zonas citrícolas en la región Este y Central llegando hasta el Suroeste. Otras iniciativas recientes sobre especies invasivas en la R.D. fueron: (1) el establecimiento de la base de datos sobre el país para la IABIN, (2) la realización del V. Simposio del Caribbean sobre Biodiversidad, (3) un programa para la detección de moscas de las frutas exóticas, (4) un estudio sobre la distribución y plantas hospederas de moscas de las frutas reportadas, así como (5) una evaluación de atrayentes y trampas para moscas de las frutas, (6) la emergencia de parasitoides de diferentes frutas, especialmente de mangos y *Spondias* spp., y (7) diferentes investigaciones sobre plagas artrópodas invasivas severas como la mosca asiática del guandul (*Melanagromyza obtusa*), incluyendo sondeos sobre daños, distribución y enemigos naturales, trampeo, plantas hospederas, control químico y respuesta varietal. Debido a la ausencia de parasitoides natives efectivos en guandul, el control biológico clásico es considerado como necesario. Sin embargo, la primera introducción de especímenes desde Australia con propósito de cuarentena y reproducción falló. Otra plaga invasiva con impacto económico es el ácaro tarsonémido del arroz (*Steneotarsonemus spinki*), el cual luego de años de relative estabilidad en rendimientos, nuevamente ha causado daños severos en asociación con enfermedades causadas por hongos. Una propuesta en MIP para el arroz está siendo sometida por el IDIAF. La araña africana (*Cyrtophora citricola*), considerada como plaga de los cítricos y otras frutas, en pocos años se ha diseminado en toda la isla de Hispaniola. El 'amarillamiento letal de los cocoteros' fue reconfirmado por PCR en 1997. A pesar de que su vector *Myndus crudus* no ha sido detectado, la enfermedad se ha diseminado lentamente hacia el este en la costa norte, aproximándose a la zona principal de producción del coco en el Noreste. Fueron mencionados los mayores riesgos por especies invasivas (plagas y patógenos) y sus respectivos países y/o áreas de distribución en la región. También se incluyó una lista de 441 interceptaciones realizadas sobre 24 productos comerciales transportados (Enero 2003-Oct. 2005) a puertos de entrada de los E.U.A. (incl. Puerto Rico e Islas Vírgenes), la cual muestra importantes tipos de plagas asociadas a cada tipo de producto. Además se presentan ejemplos de interceptaciones de insectos, posiblemente 'pasajeros' sobre aguacate en puertos marítimos de los E.U.A. y de artrópodos y patógenos reportados en productos importados hacia la R.D. Una comparación entre diferentes regiones de las Américas como orígenes de plagas exóticas transportadas hacia los E.U.A. por aviones, demuestra la relativamente baja importancia de la República Dominicana y las Indias Occidentales, comparado con América Central.

INTRODUCTION

Increased international exchange of agricultural goods and travelers has augmented the risk and the frequency of introduction of exotic plant and pest species throughout the Caribbean Region. Thus the Dominican Republic (DR), which covers the eastern two thirds of the Island of Hispaniola, has suffered the introduction of dozens of harmful exotic species, as well. Several of these species present a high invasive potential and have caused significant economic losses to affected crops within intensive agro-ecosystems, displacement of native species and/or interference with the balance of nature in susceptible ecosystems. The main reasons for this trend have to do with:

- An insufficiently effective quarantine system, albeit one that is steadily improving,
- A 300 km-long western DR-Haiti border, which is porous to the entry of pests, and
- the occurrence of tropical storms and hurricanes, which can spread certain 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, which cause direct yield losses to crops, and/or reductions in quality of harvested products, and increase costs of production. Consequently production of some affected crops becomes unprofitable and unsustainable with severe socio-economic effects. Such impacts were suffered during the early 1990s when the *Bemisia*-Geminivirus complex destroyed the production of tomatoes and other host crops in the DR.
- Loss of export markets: Alien pests often cause restrictions or bans on potentially infested or infected products intended for export to countries where these pests or plant pathogens have a quarantine status. This has severe economic implications to the producers, and they 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.

A review was given by Serra *et al.* (2003a) on selected examples concerning their detection, impact and measures taken to face the problems. In addition to several dozen invasive alien plant species, the 37 most important exotic pest species reported between 1975 and 2003 in the DR belong to the taxonomic groupings listed in Table 1.

The number of introduced alien pest species during the last three decades could be considered even higher, as the taxonomic revision of several species has to be undertaken by a multidisciplinary team under the guidance of pertinent authorities. In most cases involving arthropods, the lack of effective indigenous natural enemies has allowed quick dispersal of the introduced pests. This has occurred with aphids and whiteflies that vector viruses, as well as mealybugs, thrips, fruit flies, the coffee-berry borer (*Hypothenemus hampei* Ferr.) and, recently, with the pigeon pea pod fly (*Melanagromyza obtusa* [Malloch]).

Experience has shown that many introduced alien species become firmly established and in a relatively short period, those with strong invasive potential, spread into agrarian or wild environments (Abud-Antún 1995b; IABIN 2002; Serra et al. 2003a, b; Serra et al. 2004). Reports on introduced arthropods, plant pathogens and invasive plant species seldom explain why they arrived, the country of origin, the port of entry, and their distribution. Sometimes such information may be obtained *ex post facto* after these species have caused economic damage to crops or other serious problems. In many cases, the absence of specific antagonists of highly damaging introduced alien species has permitted them to spread rapidly throughout the country.

To date, no successful eradication of any invasive alien species in the DR has been reported. However, in some cases, the planned or accidental introductions of exotic antagonists and/or adaptation of native enemies have resulted in dramatic population suppression of alien species, often below economic-damage levels, as in the cases of the citrus blackfly (*Aleurocanthus woglumi* Ashby), citrus leafminer (*Phyllocnistis citrella* Stainton), brown rice bug *(Tibraca limbativentris* [Stål.]), coffee-berry borer and the papaya mealybug (*Paracoccus marginatus* Williams & Granara de Willink).

In the case of the pink hibiscus mealybug, *Maconellicoccus hirsutus* [Green], the presence of parasitoid species, especially *Gyranosoidea indica* Shaffee, Alam & Agarwal (probably introduced together with the pest), and the predacious mealybug destroyer, *Cryptolaemus montrouzieri* Mulsant, established since the 1930s, and the implementation of classical

biocontrol by the introduction of *G. indica* and *Anagyrus kamali* de Moursi have prevented damage levels comparable to those suffered in the Lesser Antilles during the last decade (Abud-Antún 1992; Meyerdirk & De Chi 2002; Serra 2005; Serra *et al.* 2004; Taveras 2000).

INVASIVE SPECIES INITIATIVES IN THE DR. (2002-2005)

A. Exchange of information:

Electronic Workshop on Invasive Species Threats in the Caribbean: As part of an initiative of Nature Conservancy and the CAB International, Caribbean & Latin American Regional Centre, this electronic workshop was conducted in April 2003 with >250 specialists from different countries and areas of expertise. The exchange among participants lasted for many additional month. As a result, the workshop came up with a list of alien species introduced to the Caribbean including 552 exotic spp., from which 446 species were considered as naturalized and/or invasive species; among those, 186 and 147 species were listed for the DR., respectively (see Kairo et al.(2003).

Inter-American Biodiversity Information Network (IABIN 2002): A database on invasive biological species in the DR has resulted in the participation of 54 experts from different areas of expertise and 23 national institutions related to the agricultural sector or environmental issues (11 governmental, 6 NGOs, 4 academic and 2 private). Several goals were attained: (1) the establishment of a catalog on invasive species, (2) the assembly of a list of national experts and institutions involved in management of invasive species, and (3) the inclusion of the information in the IABIN-WEB in 2003. Specifically, a total of 154 invasive species were proposed, and their taxonomic groupings are listed in Table 2.

Among the 61 proposed invasive plant species, most were introduced as crops, ornamentals, and/or for reforestation or other purposes. The participating experts identified the need of inclusion of new invasive plant species and the revision of some established invasive species to establish the true status and impact the latter on agrarian and wild ecosystems. During the IVth Caribbean Biodiversity Symposium, held in Santo Domingo in January 2005, a national workshop to evaluate and confirm the proposed invasive species was suggested.

Among 27 listed insect species, over 50% belong to the orders Homoptera (8 spp.), Coleoptera (4) and Lepidoptera (3), while the remaining were Diptera (2), Heteroptera (2), Thysanoptera (2) and Hymenoptera (1). There is also an urgent need to compile a pest list (arthropods and pathogens), and it should include species listed by Serra *et al.* (2003) and recent detections of the Plant Protection Department (DSV) of the Ministry of Agriculture (S.E.A.). The presence, distribution, host range as well as the actual status of these and other still unreported pest species must be verified or confirmed by the pertinent national authorities. The need for a current official pest list is illustrated by the case of the still officially unreported Passionvine or Pacific mealybug, *Planococcus minor* (Maskell) (Hemiptera: Sternorrhyncha: Pseudococcidae), a pest that has been intercepted 75 times since 1986 by USDA/APHIS on shipments from the DR on more than 23 hosts at 7 U.S. ports of entry (USDA/APHIS, unpubl. interception data).

The Plant Protection Department (S.E.A.) has been involved in several activities concerning invasive species and has received the support of the U.S. Department of Agriculture (USDA/APHIS) for the following programs or activities:

- Program for detection and identification of exotic fruit flies;
- Participation in a survey on the distribution of the recently introduced lime swallowtail, *Papilio demoleus* L. (Lepidoptera: Papilionidae) (Guerrero *et al.* 2004);
- Pre-inspection and pre-clearence program;

- First certified hot-water treatment plant near Moca, Province Espaillat, against larvae of fruit flies in order to certify mangoes for the export to the U.S.;
- Recently initiated biological control program for fruit flies (*Anastrepha* spp.) with *Dorybracton areolatus* (Szépligeti) (Hymenoptera: Braconidae) in two pilot zones (Hato Damas, south-central Province of San Cristóbal, and Mata Larga, north-eastern Province Duarte) with the participation of IDIAF and UASD. Preliminary results indicate that specimens of the introduced species are being recovered from sampled *Spondias* spp. fruits (Serra, unpubl.).

B. Research:

- A research team of the School of Agronomy of the Universidad Autónoma de Santo Domingo (UASD) is carrying out a nationwide survey on the distribution and host plants of *Anastrepha* fruit flies in the DR. No preliminary data are available, yet.
- In collaboration with the University of Guadalajara, Mexico, researchers of UASD and IDIAF have assisted studies on the host preference, distribution, natural enemies and control of cactus moth (*Cactoblastis cactorum* (Bergroth), Lepidoptera: Pyralidae);
- The Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) has carried out through its National Plant Protection Program (PNPV) the following research projects on invasive pests or diseases:
  1. Pigeon pea pod fly (*Melanagromyza obtusa* (Malloch), Diptera: Agromyzidae): Surveys on damage, distribution and natural enemies, chemical control, varietal responses, trapping, host-plant range (USDA/APHIS) for the pigeon pea pod fly;
  2. Fruit fly trapping: *Anastrepha* spp. (Diptera: Tephritididae): Trapping of fruit flies *Anastrepha* spp. with different attractants and traps;
  3. Fruit Fly parasitoids. Survey of native parasitoids of fruit flies *Anastrepha* spp. on mangoes, guava, hog plums (*Spondias mombin* and *S. purpurea*) and other fruits. Parasitoids, *Utetes anastrephae* (Viereck) (Hymenoptera: Braconidae), were only recorded on *Spondias* spp. and a classical biological control project (DSV-USDA/APHIS-IDIAF-UASD) with *Dorybracton areolatus* (Szépl.) initiated in June 2005.
  4. Coconut Lethal Yellowing Disease (CLYD): CLYD was reported in the DR by Walter Carter in 1962 and later confirmed. In thrusts beginning in 1969, 1995 and 1998 the authorities (S.E.A.) implemented preventive measures (cutting and burning symptomatic palms) in order to prevent dissemination of the disease within the areas of production, even though these measures did not give good results in other countries. Again in 1997, CLYD was confirmed by PCR by the Mexican Centro de Investigación Científica de Yucatán (CICY). Surveys (2003-2004) carried out in different localities of the provinces of Santiago, Puerto Plata (Sosua, Cabarrete and Cofresí) and Dajabón, showed a high CLYD incidence in the latter and in the touristic zone of Cabarrete. In 2004 for the first time, symptomatic plants were seen in Río San Juan, which indicates a slow but steady movement eastwards towards Nagua, edge of the main coconut-producing region of the DR. Yet, no known vector, e.g., *Myndus crudus* (van Duzee) (Hemiptera: Auchenorrhyncha: Cixiidae), has been detected in the DR. In July 2004 during aerial and terrestrial survey activities in close cooperation with Dr. Carlos Oropeza (CICY), researchers of IDIAF did not find any infected plants in the South but 30 plants in Puerto Plata. During the Latin American meeting of REDBIO in 2004, a network on CLYD was established for Latin America and the Caribbean (REDCAL).

5. Spotted and unfilled grains in rice: An IPM proposal for rice has been submitted by the National Program for Cereals together with the PNPV, both of IDIAF. It includes studies on the biotic and abiotic factors involved in the symptoms, e.g. on the invasive rice spinky mite (*Steneotarsonemus spinki* Smiley), detected in 1998 and probably introduced from Cuba, one if not the main causal agent of abnormal symptoms in rice, certainly also associated to fungal diseases like *Sarocladium oryzae* (Sawada). Research on tolerant varieties and chemical control has been carried out at IDIAF and private firms. As a consequence a tolerant variety (Prosequisa-4) was planted in more than 80% of the wetland-rice areas. New, more tolerant materials are being tested or have been introduced (IDIAF-1), but still the mite problem persists.

C. Status of some invasive pest species recently reported established in the DR:

- Lime, lemon or chequered swallowtail. *Papilio demoleus* L. (Lepidoptera: Papilionidae) was reported in a student's collection (Tilden 1968) in California but its presence there has not been confirmed. This is the first New World documentation of this Old World citrus pest (Guerrero *et al.* 2004). The species was reported as very devastating to young citrus groves and to be very invasive in Southeast Asia. Since the 1970s, *P. demoleus* 'jumped' from island to island in Indonesia and the Philippines and is now widespread in Southern Asia. It is a major threat to the citrus industries of the wider Caribbean including Florida because of the Region's favorable climatic conditions (heat and humidity), which allow the pest to complete up to 6 generations per year, the lack of population–controlling natural enemies, a wide host range among *Citrus* spp. and the widespread distribution of citrus trees on Hispaniola and in the Caribbean.

  The Old World island system resembles that of the West Indies, where citrus groves have been established on formerly deforested areas. Damage levels, host range, bio-ecological data and natural enemies of *P. demoleus* in Asia have been studied by Guerrero *et al.* (2004). Wehling (pers.comm.), found *P. demoleus* to be more abundant than the native citrus-feeding *Papilio* spp., in any site where it had been found by Guerrero *et al.* (2004). The specimens collected in the DR resemble populations of *P. demoleus malayanus* from Southeast Asia. After the first detection of *P. demoleus* in March 2003 in Veron, Punta Cana, Province Altagracia, at the eastern edge of the country, an international team found it in citrus groves of Villa Altagracia, about 200 km west from the sites where the pest had been found originally: Cotui (Prov. Sánchez Ramírez) and Bayaguana (Prov. Monte Plata), but not in Jarabacoa (Prov. La Vega) nor Hato Mayor. Since then, *P. demoleus* has been confirmed in Santo Domingo Norte (Serra, unpubl.) and in Baní, Azua and Jarabacoa (Virgil, pers. comm.). There is a need to more accurately determine the distribution and status of this invasive pest in the DR.
- Pest species introduced to the DR at unknown dates before 1995, and not been listed in Serra *et al.* (2003), are found in Table 3 (Abud-Antún 1995; Schmutterer 1990; Wagner and Colon 2002):
- Tropical tent-web spider, *Cyrtophora citricola* (Forsköl) (Aranae: Araneidae), is actually wide spread in the lowlands of the DR where it is causing some damage, mainly in citrus orchards;
- Passionvine or Pacific mealybug, *Planococcus minor* (Maskell) (Hemiptera: Sternorrhyncha: Pseudococcidae). Between 1986 and 2005, 75 interceptions from the DR were reported at 7 U.S. airports; but no report of the current status of *P. minor* in the DR available, and its presence has yet to be confirmed by local authorities;
- Oriental cocoa mealybug, *Planococcus lilacinus* (Cockerell), Hemiptera: Sternorrhyncha: Pseudococcidae, has been reported to be present in the DR (Miller *et al.* 2001), and has the

potential to cause economic losses to cocoa, citrus, guava and mango. Nevertheless, no reports on damage are available and its presence has yet to be confirmed by local authorities.

D. Major external threats to the DR from exotic invasive arthropod pests and invasive pathogens.

Arthropod pest species which are major external threats to agriculture in the DR are listed in Table 4 (Serra *et al.* 2003). These pests are already well established elsewhere in the Caribbean region.

Some major plant pathogens that threaten cocoa and citrus production of the DR (reported in Serra *et al.* (2003) have continued to spread in the Caribbean and have come closer to the DR. These include the following:

- 'witches broom' (*Crinipellis perniciosa* [Stahel]) originating from northwestern South America is present in the Caribbean (Grenada, St. Vincent, Trinidad & Tobago) and has recently been detected in Chiapas, Mexico;
- 'frosty pod rot' (*Moniliophthora roreri* (Cicero & Parodi), damaging cocoa production with up to 60% infection in South and Central America. Introduction into the DR of frosty pod rot would have severe consequences for the production of certified organic cocoa, in which the DR is the world leader due to the absence of fungicide spraying;
- 'citrus greening', a bacterial disease (*Liberobacter asiaticus*) transmitted by the Asiatic citrus psyllid, *Diaphorina citri* Kuwayama, is now present in Florida (prob. Asian race) (Sainz, 2005). The vector is already present in the DR (Serra *et al.* 2003);
- 'citrus canker' (*Xanthomonas axonopodis* (Hasse) pv *citri*), present in Brazil and Florida.

The arthropod pest and disease species listed above pose serious challenges to DR's national surveillance system. In spite of its steady improvement, the entry into the DR of new exotic invasive species on several occasions has not been avoided. Rejected or treated containers with imported agricultural commodities containing quarantine pests or diseases have been found in the DR; and these included *Tilletia* sp. on rice from the U.S.A., *Dacus* sp. on a non-specified fruit from Spain and unidentified beetle species of the families Bostrichidae (grain borers) and Cerambycidae (longhorn beetles) in packing material from Spain (Bueno, SEA/DSV, personal communication).

E. The relative importance of the DR as a source of invasive species.

In spite of pre-inspection measures, quarantine pests in commodities exported from the DR have been detected in foreign ports. An extract of 954 pest interception records in the national database of APHIS-PPQ pertaining to all Dominican Republic commodities commercially shipped to U.S. ports of entry from January, 2003 through October, 2005 is summarized in Table 5. The ports of entry include Puerto Rico and the U.S. Virgin Islands. The listed interceptions were recorded on commodities shipped by airplane, ship or reported from inspection stations which inspected plant and/or seeds for propagation. For each exported commodity the list presents significant, host-associated types of pests from the 23 represented crop species or genera. Although the pest list gives important information on the status of DR commodities entering the U.S.A., some of the listed species or genera have not been reported by Dominican authorities and their presence in the DR must be considered to be uncertain until their existence in the country is officially recognized. Some commodities exported to the USA were not mentioned in Table 5, e.g. avocado, *Persea americana,* and some genera of cut flowers, and this suggests that no quarantine pests were found on them. However recent 'Miami Maritime Interception Reports' (USDA/APHIS, unpubl.),

stated that several pests were detected on shipments of fresh avocado fruits originating from the DR (Table 6). None of these species is considered to be a pest of economic importance for avocado and could have been intercepted as opportunistic 'hitchhikers'. Nevertheless, the exact pathway of entry of these pests should be determined.

Information on the relative importance of the DR as a country of origin for infested commodities transported by airplane in an international and regional context was obtained through a study by Dobbs & Brodel (2004) conducted between September 1998 and August 1999 (Table 7). These authors demonstrated the importance of cargo aircraft as a pathway for the entry of non-indigenous insects to the U.S.A. The detected insects belonged to 33 families in 5 orders, but mostly to the Lepidoptera and Coleoptera, and multiple insect taxa were represented in >40% of infested airplanes. The results suggested the relative importance of various regions and countries as potential origins for the introduced pests by this pathway.

However, statisticians consulted considered that while reliable conclusions could be drawn from such data collected for Central and South America, similar comparisons among countries within the West Indies were not statistically valid because the number of sampled aircraft for the region was too small. Nevertheless, these inconclusive data concerning the DR published by Dobbs and Brodel (2004) - being the only relevant data available – are presented in Table 7, since they do suggest a correlation between the number of introductions of exotic pests with the relative strength of inspection and quarantine systems.

The approach rate of quarantine pests from the West Indies of 3.3% was slightly lower than that from South America, but significantly lower than the rate from Central America including Mexico. It must be pointed out that the authors found marked differences among the countries. Seasonal factors played a role in the approach rates for Central America (wet 28.9% vs. dry 15.7%). Approach rates for the West Indies – based on very limited data - varied: 0 (12 countries), 2.9% (DR), 8.3% (Jamaica) and 18.2% (Haiti). Among these, sampled cargo airplanes from the DR represented 5% of the total number of aircraft inspected from all origins. The single infested airplane from the DR represented 25% of the total infested airplanes from the West Indies region. Relatively weak institutions with respect to quarantine and plant health inspections and/or unstable political conditions may have influenced the results pertaining to countries with relatively high approach rates.

CONCLUSIONS

International trade agreements require effective mechanisms to prevent the export or entrance of invasive alien species, their quick localization and isolation and in some cases their eradication or management in order to avoid penalties and loss of markets because exportable agricultural goods do not meet the phytosanitary requirements of the importing country. During recent years, establishment of invasive alien species in the Dominican Republic has been reported with increased frequency, especially arthropods and plant pathogens. The introduction of many species certainly occurred long before their populations reached outbreak levels. Several dangerous exotic invasive pests, diseases and plants already present elsewhere in the Caribbean seriously threaten the economy of the Dominican Republic. Severe economic consequences would attend the establishment of such species, e.g. the mangoseed weevil could lead to serious restrictions for export of mangos to the U.S.A. and torpedo efforts of the national mango sector to increase its participation on the world market.

Numerous suggestions for area-wide pest management programs as phytosanitary measures have been made during the present and former symposia on invasive species. An improved ´forecast´ system for the Caribbean through capacity building to assure the quick detection and surveillance of recently introduced exotic species in the Caribbean region and a broad

international and inter-institutional network for data exchange are part of the determined goals. The respect of the confidentiality of the information until the national authorities (Plant Protection Departments, Ministries, etc.) report the existence of a pest is a concern, not only in the DR, due to the threat of economic implications as a consequence of a ban or restriction on the exportation of an affected commodity. The support of biological control programs in the region and foreign exploration of natural enemies of potential pests to come before the latter have entered has to play a special role in the mitigation of the impacts of invasive species throughout the region. The lack of resources both for research and the conduct of management programs for invasive pest species in some countries of the region make necessary the inclusion of national structures of those countries into a participative international network. Nevertheless, it is necessary to revise existing protocols for strengthening possibly deficient aspects of the in-country safeguarding strategy (e.g. the quarantine system), and to find ways to support regional efforts. These and other more specific topics should be debated on a national level in the Dominican Republic by competent authorities, and by affected sectors of the society in order to develop a national agenda, which should include the following topics (Serra *et al.* 2003):

- Characterization of the threats and impacts 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 invasive species, identification of gaps and opportunities for improvement.
- Development of recommendations for improvements and opportunities for partnerships to reduce the threat of invasive species, especially those with multiple-site impact.
- Determination of gaps and opportunities concerning the phytosanitary deficiencies on the level of the shared island of Hispaniola (Haiti and DR).

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Table 1. Taxonomic groupings of invasive alien species in the Dominican Republic (Serra *et al.* 2003).

Arthropods: 23 - 16 Insect species: Hemiptera: 7 Sternorrhyncha, 1 Auchenorrhyncha; 2 Heteroptera; 2 Thysanoptera, 2 Diptera, 1 Coleoptera, 1 Lepidoptera sp. - 7 Arachnid Species: 6 Mites & 1 Spider	**Molluscs: 1** **Plant pathogens: 13** - 5 fungi, - 2 bacteria, - 1 phytoplasma, - 5 viruses

Table 2. Classification of 154 invasive species proposed for the Dominican Republic (IABIN database).

Plants:	61	Fungal pathogens:	3	Vertebrates:	52
- Graminae	13	Invertebrates:	38	- Fishes	16
- Asteraceae	8	- Molluscs	5	- Amphibians	5
- Ornamentals	10	- Crustaceae	1	- Reptiles	3
- Forestry species	12	- Acari	5	- Birds	15
- Fruit species	3	- Insects	27	- Mammals	13

Table 3. Pests introduced to the Dominican Republic in addition to those listed by Serra *et al.* 2003a.

Latin Name	Common Name	Order: Family
Aceria tulipae (Keifer)	Tulip bulb mite	Acari: Eriophyidae
Aulacaspis tubercularis Newst.	White mango scale	Hemiptera: Diaspididae
Orthezia praelonga Dougl.	Citrus coccid	Hemiptera: Ortheziidae
Araecerus fasciculatus de Geer	Coffee bean weevil	Coleoptera: Anthribidae
Conotrachelus sapotae Barber	Sapotilla weevil	Coleoptera: Curculionidae
Cactoblastis cactorum (Bergroth)	Cactus moth	Lepidoptera: Pyralidae
Lehmannia valentiana (Fer.)	Spanish slug	Stylommatophora: Limacidae

Table 4. Invasive species in the wider Caribbean region that immediately threaten the DR.

Exotic Species:	Presence in the Region:
Exotic fruit flies:	
Anastrepha ludens (Loew), *Anastrepha* spp., *Bactrocera* **carambolae** Drew & Hancock, *Ceratitis capitata* (Wied.)	Northern South America and/or Central America
Mango seed weevil, *Sternochetus mangiferae* (F.)	Lesser Antilles, Cuba
South American palm weevil, *Rhynchophorus palmarum* (L.)	Northern South America
Sweet Potato Whitefly, *Bemisia tabaci* (Genn.) *'Q biotype'*	Europe, Southwestern U.S.A, Florida
Cycad scale, *Aulacaspis yatsumatsui* Takagi	Puerto Rico, Florida, Guadeloupe
Lobate lac scale, *Paratachardina lobata lobata* (Chamb.)	Florida, The Bahamas
Pepper weevil, *Anthonomus eugenii* Cano	Florida, Mexico
Avocado seed moth, *Stenoma catenifer* Walsh.	Mexico, Panama, South America
Chili thrips, *Scirtothrips dorsalis* Hood	Barbados, Florida, St. Lucia, St. Vincent & Grenadines, Suriname, Trinidad & Tobago
Red fire ant, *Solenopsis invicta* Buren	Puerto Rico, Florida, Brazil
Tropical bont tick, *Amblyomma variegatum* (Fabr.)	Lesser Antilles
African giant snail, *Achatina fulica* (Bowd.)	Lesser Antilles
Tropical soda apple, *Solanum viarum* Dunal	Puerto Rico, Florida, South America

Table 5. Pest interceptions on commodities commercially shipped from the Dominican Republic to U.S. ports of entry (incl. Puerto Rico and U.S. Virgin Islands) (APHIS-PPQ, unpubl. data)

Host	Air	Sea	I/S*	Pest Species	Freq-quency
Adenium sp.			X	*Calcisuccinea dominicensis*	1
Ananas comosus			X	Veronicellidae sp.	3
Artocarpus altilis	X			*Dysmicoccus neobrevipes*	2
				Dysmicoccus sp.	3
				Planococcus minor	3
				Pseudococcidae (immatures)	8
				Thrips palmi	1
A. heterophyllus	X			*Melanagromyza* sp.	12
Cajanus cajan	X			Cecidomyiidae sp.	2
Capsicum sp.	X	X		Noctuidae sp.	13
				Pentatomidae (immatures)	11
				Thrips palmi	5
				Veronicellidae sp.	1
				Dysmicoccus sp.	3
Citrus sp.		X		Pseudococcidae (immatures)	8
				Diaphania sp. *indica* complex	2
Cucumis sativus		X		*Thrips palmi*	1
				Pterophoridae sp.	33
Cucurbita sp. (incl. *C. pepo*)	X			*Cercospora* sp.	11
	X	X		*Veronicella* sp.	1
Eryngium foetidum				*Calcisuccinea dominicensis*	1
			X	Tetranychidae sp. (eggs)	8
Evolvulus sp.				Pterophoridae sp.	9
	X	X		Aleyrodidae sp.	5
Lagenaria siceraria			X	*Diaphania* sp. *indica* complex	22
Lantana sp.	X			Pterophoridae sp.	2
Luffa sp.				*Thrips palmi*	10
				Veronicella sp.	1
				Anastrepha sp.	1
		X		*Chaetanaphothrips leeuweni*	2
Mangifera indica	X			Margarodidae sp.	2
Melicoccus bijugatus				Pseudococcidae (immatures)	8
				Diaphania sp. *indica* complex	43
	X			*Metamasius hemipterus*	1
Momordica sp. (incl. *M. balsamina* & *M. charantia*)				*Thrips palmi*	107
				Veronicella sp.	1

Table 5 continued.

Host	Air	Sea	I/S*	Pest	Freq-quency
Musa sp.	X	X		*Dysmicoccus neobrevipes*	4
				Planococcus minor	2
				Pseudococcus elisae	1
				Metamasius hemipterus	1
Phaseolus sp.	X			*Maruca vitrata*	4
Solanum melongena	X			*Planococcus minor*	1
				Pseudococcidae (immatures)	7
				Thrips palmi	24
Solidago sp.	X			Miridae (immatures)	23
				Nysius sp.	2
Vigna sp.	X			*Chalcodermus* sp.	2
				Maruca vitrata	15
				Thrips palmi	5
Wood		X		*Nasutitermes costalis*	2

I/S = Inspection Station; designates that plants and/or seeds for propagation are being shipped.

Table 6. Some recent U.S. interceptions of quarantine pests on avocado, *Persea americana*, originating in the DR (USDA/APHIS, unpubl. data).

December 2004:	**January 2005:**
Eulepidotis juncida (Lepidoptera: Noctuidae), *Scudderia* sp. (Orthoptera: Tettigoniidae)	*Aeolus* sp. (Coleoptera: Elateridae), *Utetheisa* sp. (Lepidoptera: Arctiidae), Gryllidae sp. (Orthoptera: Gryllidae)

Table 7. Importance of different regions and the DR as origins of pests transported in cargo aircraft to the U.S.A. (modified from Dobbs & Brodel 2004).

Origin:	**Airplanes sampled**	**Airplanes infested**	**Approach rate (%)***
Overall:	703 (100%)	73	10.4 (0 – 50)
- Central America:	207 (29.4%)	48	23.2 (12.1 – 50)
- South America:	346 (49.2%)	20	5.8 (0 – 15.9)
- West Indies:	122 (17.3%)	4	3.3 (0 – 18.2)
- Haiti	11(1.6%)	2	18.2
- DR	35 (5%)	1	2.9

* Mean per region; range in brackets being the lowest and highest values among the countries. Differences between the means for Haiti and the DR are not significant statistically.